CHAPTER 2

GEOLOGIC SETTING

Geologic information of the study area and adjacent parts has been reported on the 1:250,000 scale geologic map, sheet 2 (Chiang Rai) by Bruan and Hahn (1976), and on the geologic maps at a scale 1:50,000, sheets Ban Mae Pao Luang and Amphoe Thoeng by Sukvattananunt *et al.* (1985). More detailed geologic mapping of this area was recently carried out by undergraduate students of Department of Geological Sciences, Chiang Mai University (Chankaeo *et al.*, 1996; Mahatthanachai *et al.*, 1996; Lee-am *et al.*, 1996; Pongsaeree *et al.*, 1996; Thiankham *et al.*, 1996; and Chat-prasert *et al.*, 1996) under the supervision of Associate Professor Dr. Y. Panjasawatwong, Dr. W. Kandharosa, and Dr. P. Wongpornchai. According to these informative data, the project area is constituted by a number of rock units that may be lithologically either sedimentary or igneous, and have different ages ranging from the Permian to the Recent (Fig. 3). Individual rock units and their structures will be described below.

2.1 Permian Rocks

Permian rocks can be divided into three units, stratigraphically from bottom to top as follows: limestone, sedimentary-pyroclastic sequence, and sedimentary sequence.

2.1.1 Permian limestone

Permian limestone, the lowermost rock unit in the study area, exposes as small isolated hills in Quaternary deposit on the southwest of the study area and has a total thickness of about 200-300 m. It has light-dark gray to black colors and medium to thick beds, and shows slightly recrystalline features. It lies in NNE-SSW direction and is fossiliferous with fusulinid, crinoid, gastropod and conodont. The ages of this unit, obtained from fusulinid, conodont, and gastropod and microfossil, are the Lower (to Middle?) Permian, the Upper Carboniferous to Permian, and the Middle to Upper Permian, respectively (Sukvattananunt *et al.*, 1985). Therefore, the age of this limestone unit is most likely to be the Middle Permian.

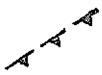
2.1.2 Permian sedimentary-pyroclastic rocks

This rock unit was previously mapped as Permo-Triassic (Bruan and Hahn, 1976) or as Mesozoic (Sukvattananunt *et al.*, 1985) strata. In this study, the unit is, however, inferred to be Middle-Upper Permian in age as it conformably overlies the Middle Permian limestone and underlies the Upper Permian sedimentary sequence (Lee-am *et al.*, 1996; Thiankham *et al.*, 1996). The sequence is restricted to the southwestern portion of the project area and is made up of tuff, shale, siltstone,

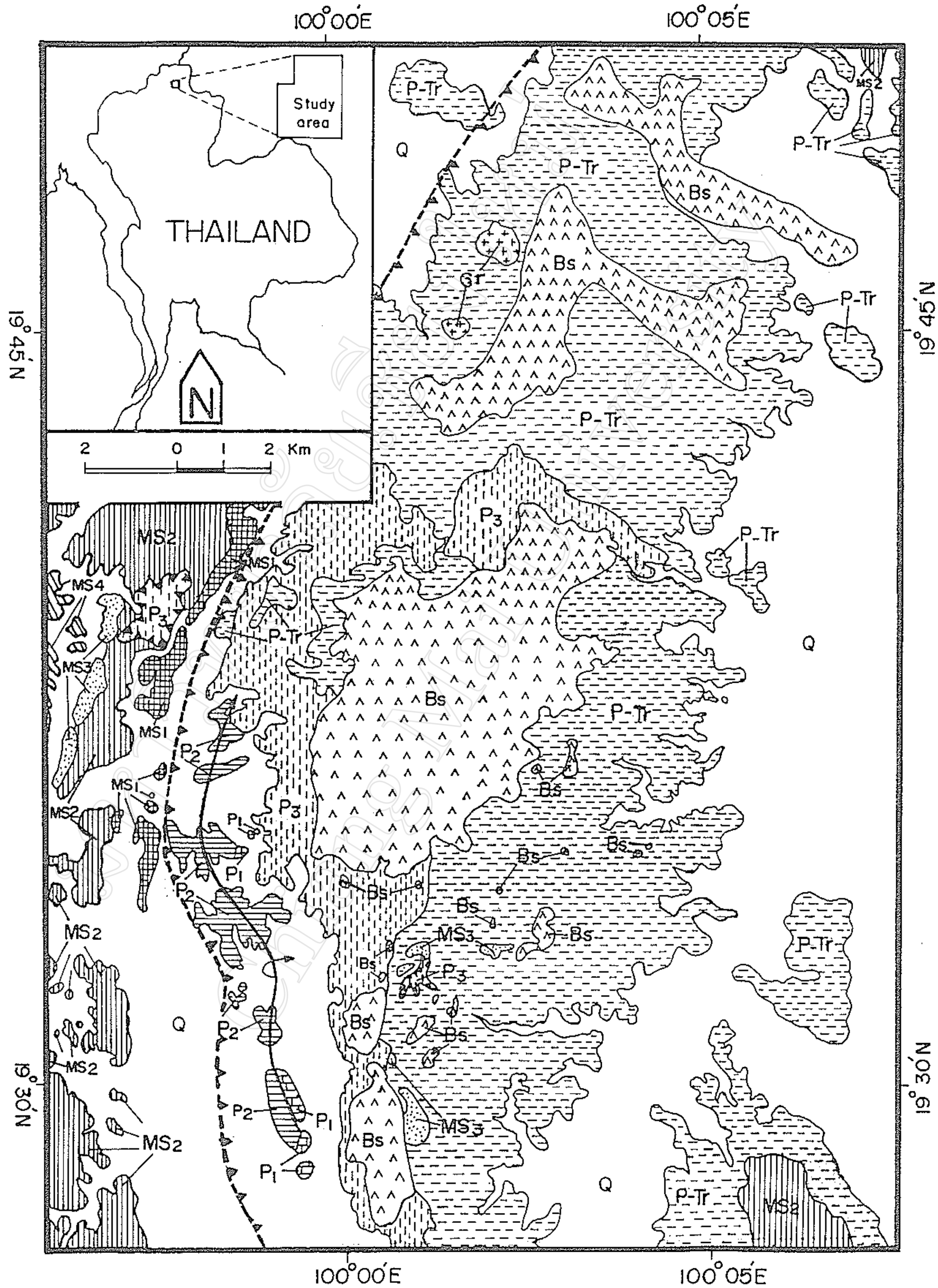
Figure 3 Simplified geologic map of the study area showing the distribution of Thoeng basalt (modified from Bruan and Hahn, 1976; Sukvattananunt *et al.*,1985; Chankaeo *et al.*, 1996; Mahatthanachai *et al.*, 1996; Lee-am *et al.*, 1996; Pongsaeree *et al.*, 1996; Thiankham *et al.*, 1996; and Chat-prasert *et al.*, 1996). See explanation and discussion in the text.

Q	Quaternary sediments
MS_4	Upper Lower Jurassic sedimentary rocks
MS_3	Lower Lower Jurassic sedimentary rocks
MS_2	Upper Triassic volcaniclastic rocks
MS_1	Upper Triassic sedimentary and pyroclastic rocks
P-Tr	Permo-Triassic rocks
P_3	Permian sedimentary rocks
P_2	Permian sedimentary-pyroclastic rocks
P_1	Permian limestone
Bs	Quaternary basalts
Gr	Triassic granite


Axis of overturned anticline with plunge, and dip direction of axial plane


Concealed thrust fault with dip direction


Boundary between rock units


100°00'E
100°05'E
19°45'N
19°30'N
Study area
THAILAND
N
2 0 1 2 Km
P-Tr
Q
Bs
Gr
P3
P2
P1
MS1
MS2
MS3
MS4

sandstone and conglomerate with a total thickness of about 80-250 m. Tuff of this unit is very thinly bedded to thinly bedded, and has grayish purple to grayish green colors. It is compositionally rhyolitic and/or dacitic, and distinctly exhibits foliation. The sedimentary strata are gray to grayish black (milky and brown where weathered) and have medium beds.

2.1.3 Permian sedimentary rocks

This sequence is composed of gray to grayish, thinly bedded to very thickly bedded black shale, siltstone, sandstone (quartz wacke, lithic graywacke and litharenite) and conglomerate with occasional basaltic lava and limestone lenses; the weathered portions of these clastic rocks yield reddish brown, yellowish brown and white colors. These rocks are approximately 350-490 m in cumulative thickness and crop out mainly in the middle portions of the study area with rough N-S trending. Shale and mudstone in this unit contain crinoid, gastropod, brachiopod and trilobite. The presence of brachiopod and leptodus signifies that this rock sequence is the Upper Permian (Sukvattananunt *et al.*, 1985).

2.2 Permo-Triassic Rocks

Permo-Triassic rocks are made up of pyroclastic rocks and tuffaceous sediments, and can be separated into lower Permo-Triassic and upper Permo-Triassic sequences.

The lower Permo-Triassic sequence unconformably overlies the Upper Permian strata and includes pale green agglomerate in the lowermost portions, and tuff intercalated with minor reddish purple shale, siltstone and sandstone (litharenite), and less common, dark green to grayish black andesitic/basaltic lavas in the upper portions (Chankaeo *et al.*, 1996; Mahatthanachai *et al.*, 1996; Lee-am *et al.*, 1996; Pongsaeree *et al.*, 1996; Thiankham *et al.*, 1996; and Chat-prasert *et al.*, 1996). Tuff comprises greenish gray andesitic tuff, pink to reddish purple rhyolitic/dacitic tuff (many are ignimbrite), and reddish purple lapilli tuff; they are thinly bedded to massive. The rock unit is approximately 200-300 m thick and mainly occupies the central part running from north to south of the project area. It is partly concealed by the Late Cenozoic basalt.

The upper Permo-Triassic sequence crops out in the eastern part of the study area and has been previously mapped as part of Mesozoic strata (Sukvattananunt *et al.*, 1985). Nevertheless, it is considered to be the upper Permo-Triassic since it is conformably underlain by the lower Permo-Triassic rock unit. In terms of lithology, the rock unit is composed of greenish to purplish tuffs (some are ignimbrite) and tuffaceous shale, and minor dark green basaltic lava. These rocks show thick beds/layers and have a total thickness of more or less 80-100 m (Mahatthanachai *et al.*, 1996; Chat-prasert *et al.*, 1996).

2.3 Mesozoic Rocks

Mesozoic rocks are constituted by Upper Triassic sedimentary and pyroclastic strata, Upper Triassic volcaniclastic rocks, lower Lower Jurassic sedimentary rocks and upper Lower Jurassic sedimentary sequence.

2.3.1 Upper Triassic sedimentary and pyroclastic rocks

These strata form a narrow belt with a rough N-S trend in the western part of the project area. They were previously mapped as part of Lower Jurassic strata (Sukvattananunt *et al.*, 1985). In this study, the age of these rocks is inferred to be the Upper Triassic following those given by Braun and Hahn (1976), Chankaeo *et al.* (1996) and Lee-am *et al.* (1996). This rock unit has purplish color and thin beds, and unconformably overlies the upper Permo-Triassic sequence. It consists of medium-grained sandstone (litharenite) interbedded with shale, conglomerate and medium to coarse tuffs (lithic tuff) with a cumulative thickness of about 200 m (Lee-am *et al.*, 1996).

2.3.2 Upper Triassic volcaniclastic rocks

This rock unit occurs as an approximately N-S trending zone to the west of the Upper Triassic sedimentary and pyroclastic strata, and in the southeast of the study area. It is gradational to the Upper Triassic sedimentary and pyroclastic strata, and is inferred to be Upper Triassic strata (Braun and Hahn, 1976; Chankaeo *et al.*, 1996; Lee-am *et al.*, 1996; Mahatthanachai *et al.*, 1996). The rocks included in this unit embrace acid to basic tuffs (many are ignimbrite), tuffaceous shale and tuffaceous sandstone with a cumulative thickness of about 100-300 m; individual beds/layers are medium to thick and their colors vary from greenish to purplish.

2.3.3 Lower Lower Jurassic sedimentary rocks

In the western part of the project area, these sedimentary strata form a narrow zone subparallel to the Upper Triassic volcaniclastic rocks; the contact nature between these two contrasting lithologies is an unconformity. In the central part, these rocks occur as small discontinuous masses unconformably overlying the lower Permo-Triassic rock. These rocks are made up of white conglomeratic sandstone interbedded with fine- to coarse-grained white sandstone (quartz arenite and litharenite), white to grayish black conglomerate and red to greenish gray siltstone (Braun and Hahn, 1976; Chankaeo *et al.*, 1996; Lee-am *et al.*, 1996; Mahatthanachai *et al.*, 1996). Individual beds of the rocks are highly variable from thick laminations to very thick beds; the total thickness of this rock unit is approximately 100-500 m.

2.3.4 Upper Lower Middle Jurassic sedimentary rocks

This sedimentary sequence occupies the northwestern part of the study area and has previously been mapped as Neogene sediments by Braun and Hahn (1976). In this account, it is considered to be part of the upper Lower Jurassic strata as it is conformably underlain by the lower Lower Jurassic sequence (Sukvattananunt *et al.*, 1985, Chankaeo *et al.*, 1996). The rocks in this unit are mainly reddish brown siltstone and white to brownish white, fine-grained sandstone (quartz arenite); medium- to coarse-grained sandstones are uncommon. Individual beds are commonly thin to thick, and occasionally laminated. Its cumulative thickness may reach 300-400 m.

2.4 Quaternary Basalts and Sediments

2.4.1 Quaternary basalts

Basalts of Pleistocene age (Barr and MacDonald, 1978) occur as scattered plateaux covering an area of approximately 85 km^2 (Fig. 3) and are known as Thoeng basalts. It unconformably overlies Permian and Permo-Triassic rocks and is commonly highly weathered to brownish red soil. Fresh basaltic outcrops are usually present along edges and slopes of mountain range. The cumulative thickness of Thoeng basalt is 45 m (Chankaeo *et al.*, 1996; Mahatthanachai *et al.*, 1996; Lee-am *et al.*, 1996; Pongsaeree *et al.*, 1996; Thiankham *et al.*, 1996; and Chat-prasert *et al.*, 1996). This basalt forms the basis of discussion, in terms of occurrence, petrography, mineral chemistry and wholerock chemistry, in the next chapters.

2.4.2 Quaternary sediments

After Jurassic period, no other sedimentary rocks have been found in the study area except for sediments of Quaternary age. The Quaternary sediments can be divided into two units as terrace and alluvial deposits. The terrace deposits are largely semiconsolidated, and made up largely of pebbles and sands derived mainly from pyroclastic rock, volcanic rock, sandstone and granite. The alluvial deposits are composed of sediments deposited from recent streams and rivers. Most of them are unconsolidated, and compositionally similar to those of the terrace deposits.

2.5 Intrusive Igneous Rocks

Intrusive igneous rocks are locally present in the project area. These include granite, microdiorite and dolerite. Granite possibly occurs as part of the main granitic body due north of the study area. It evidently intrudes the Upper Permian sedimentary sequence and the Upper Triassic volcaniclastic rocks (Chankaeo *et al.*, 1996; Mahatthanachai *et al.*, 1996). In addition, some detrital grains in the Lower Jurassic sandstone are evidently derived from granite (Mahatthanachai *et al.*, 1996; Lee-am *et* *al*., 1996; Pongsaeree *et al*., 1996; Thiankham *et al*., 1996; and Chat-prasert *et al*., 1996). As a consequence, the granite might have been emplaced during Late Triassic time. Microdiorite and dolerite form as dikes cut through the Upper Permian sedimentary sequence, the lower Permo-Triassic sequence and the Lower Jurassic sedimentary rocks, but are not crosscut the Pleistocene basalt (Chankaeo *et al*.,1996; Mahatthanachai *et al*., 1996; Lee-am *et al*., 1996; Pongsaeree *et al*., 1996; Thiankham *et al*., 1996; and Chat-prasert *et al*., 1996). This implies that they might have formed sometime between the Lower Jurassic and the Pleistocene.