CHAPTER 2

GEOLOGIC SETTING

Geology of the Lampang area has been extensively studied by many workers (Piyasin, 1971, 1972, 1974; Chonglakmani, 1972, 1981, 1982, 1983; Bunopas, 1981, 1992, 1994; Hahn and Siebenhuner, 1982; Helmcke and Lindensberg, 1983; Sengor, 1984; Bunopas and Vella, 1983; Jungyusuk and Sirinawin, 1983; Helmcke, 1985; Maneenai *et al.*, 1987; Wolfart, 1987; Chonglakmani and Helmcke, 1989; Chaodumrong and Jeumthon, 1985; Chaodumrong, 1992; Chonglakmani and Grant-Mackie, 1993; Tiyapairach, 1993; Charusiri *et al.*, 1994). Accordingly, the study area is underlain by four rock units as follows: Permo-Triassic volcanic rocks, Triassic sedimentary rocks, Tertiary sedimentary rocks, and Quaternary basalts and sediments (Fig. 4). Individual rock units are briefly described below.

2.1 Permo-Triassic Volcanic Rocks

Permo-Triassic volcanic rocks in the study area comprise rhyolite, andesite, tuff and agglomerate that are assigned to be part of the Phrae-Lampang volcanic province, Tak-Chiang Khong volcanic belt (Jungyusuk and Khositanont, 1992). They were collectively called "Mae Man volcanics" by Charusiri *et al.* (1994). These rocks are unconformably underlain by clastic rocks of the Permian Huai Tak Formation (Piyasin, 1971, 1974).

These volcanics occupy the southeastern and northern parts of the study area (Fig. 4). They generally trend northeast-southwest and form high, steep-slope mountain ranges. The total thickness of this rock unit is approximately 100 to 300 m. The rhyolitic lavas have variable colors, i.e. gray, brownish yellow, brownish red and light brown, whereas andesitic lavas are green to deep green. These lavas vary texturally from phyric to aphyric. The phyric rhyolites may contain plagioclase and

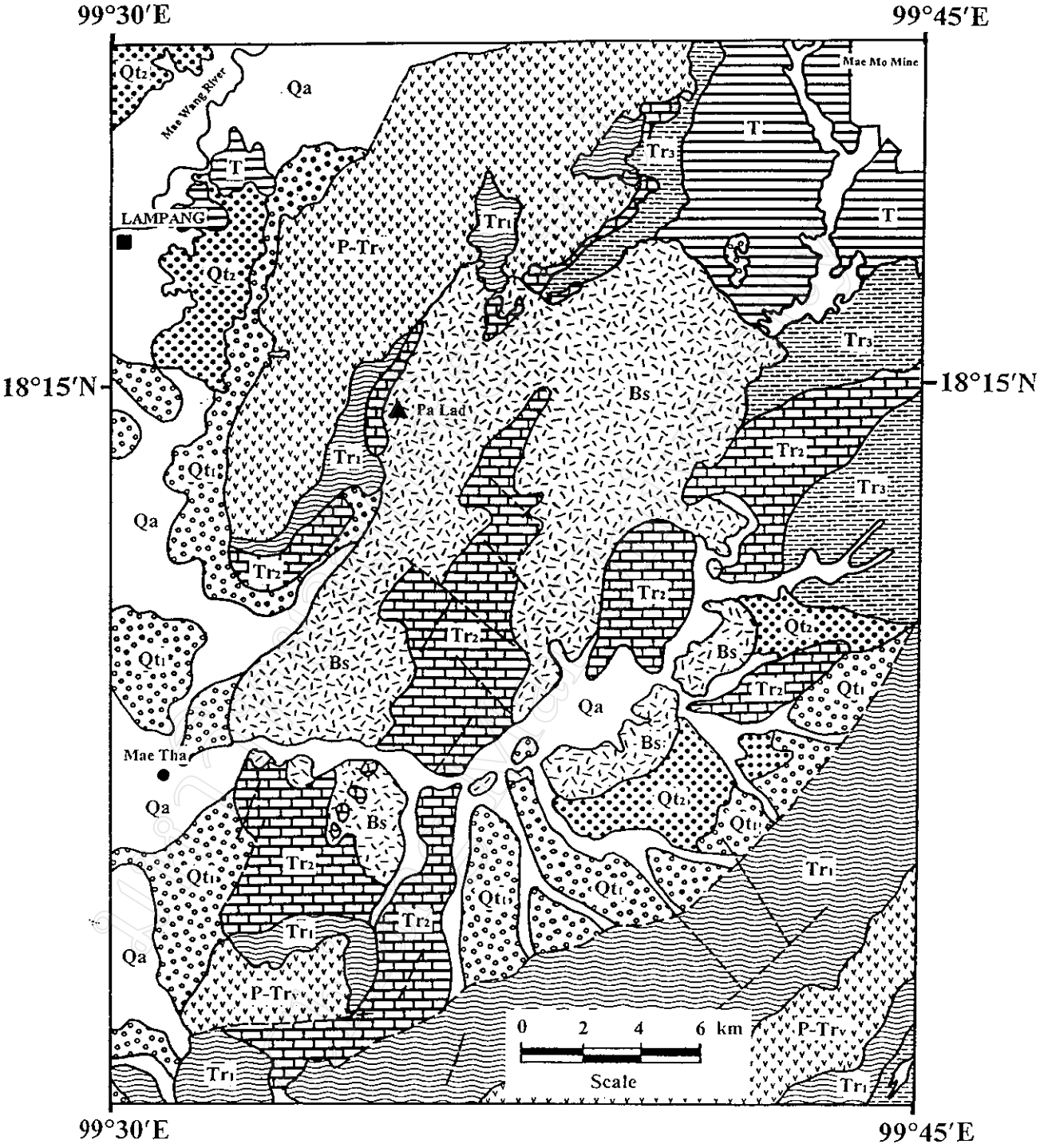

Figure 4 Simplified geologic map of the study area showing the distribution of Mae Tha Basalt (modified from Piyasin *et al.*, 1971 and 1974; Maneenai *et al.*, 1987 and Tiyapairach, 1993).

quartz phenocrysts, while the phyric andesites have plagioclase and/or hornblende as phenocryst phases. Tuffs and agglomerates are commonly associated with rhyolites and andesites. These volcanic rocks have been considered to be a magmatic arc above a westward dipping subduction zone (Bunopas, 1981; Bunopas and Vella, 1983; Hutchison, 1989; Charusiri *et al.*, 1994).

2.2 Triassic Sedimentary Rocks

Triassic sedimentary rocks present in the study area are part of the well-known Lampang Group, i.e. the Phra That, Pha Kan and Hong Hoi Formations of Chaodumrong (1992) and Charusiri *et al.* (1994). This rock unit unconformably overlies the already mentioned older Permo-Triassic volcanic rocks.

The Phra That Formation (Piyasin, 1971, 1972; Chonglakmani, 1972, 1981; and Chaodumrong, 1992; Charusiri *et al.*, 1994, the lowest formation of the lampang Group, trends northeast-southwest and has a cumulative thickness of about 200 m. This formation forms high mountain ranges in the southeastern and northern parts of the study area (Fig. 4). The rocks included are dominated by shale, siltstone, sandstone, agglomerate, and tuffaceous sandstone that are reddish brown and gray in color. The conglomerate beds in the lowest part of the formation contain pebbles, cobbles, gravels and boulders of andesite, rhyolite, sandstone, limestone, quartz, chert and shale, and are more or less 40 cm in thickness. The age of the Phra That Formation is given to be the lower Lower Triassic to lower Middle Triassic (Charusiri *et al.*, 1994). The sedimentary sequence of this formation is generally believed to have deposited in near-shore and partly continental environments with source material from the Permo-Triassic volcanic rocks (Chonglakmani, 1983; Chonglakmani and Grant-Mackie, 1993; Piyasin, 1972; and Bunopas, 1981; Chaodumrong, 1992; Charusiri *et al.*, 1994).

The Pha Kan Formation (Chaodumrong, 1992; Charusiri *et al.*, 1994) or Doi Chang Formation (Chonglakmani, 1981, 1982, 1983; Chonglakmani and Grant-

Mackie, 1993) rests conformably on the Phra That Formation and is overlain conformably by the Hong Hoi Formation. It forms as moderately high hills in the northern, western and central parts of the project area. The lithologies of this formation are massive to well-bedded, light gray to dark gray limestone with black shale, mudstone, siltstone and sandstone interbeds. They have a total thickness of about 400 - 600 m (Chaodumrong, 1992) and is lower Middle Triassic - lower Upper Triassic in age (Chonglakmani, 1983; Charusiri *et al.,* 1994). Previous investigators (e.g. Piyasin, 1972; Bunopas, 1981; Chonglakmani, 1981; Helmcke, 1985; Wolfart, 1987, Chaodumrong, 1992; Chonglakmani and Grant-Mackie, 1993) suggested that the Pha Kan/Doi Chang Formation deposited in a shallow marine platform setting, as evidenced by the presence of oncolites, oolites, benthic bivalves and brachiopods.

The Hong Hoi Formation (Piyasin, 1971, 1972; Chonglakmani, 1972, 1981; Chonglakmani and Grant-Mackie, 1993; Charusiri *et al.,* 1994) normally forms rolling topography that is widespread in the northeastern part of the study area. It is partially covered by Quaternary basalts and unconsolidated sediments. This formation is composed of shale interbedded with mudstone, siltstone and sandstone; limestone lens has been locally observed. These rocks have colors varying from greenish gray to gray and dark gray to black. They have been assigned to be a turbidite sequence (Chaodumrong, 1992) of the Upper Triassic (Charusiri *et al.,* 1994). The sandstone is fine- to medium-grained, well sorted and well rounded, with high sphericity. The cumulative thickness of this formation is about 700 m. The depositional environments of the sediments grouped as the Hong Hoi Formation have been interpreted in different ways; e.g. forearc sediments (Bunopas, 1981; Chonglakmani, 1982; Sengor, 1984), neritic sediments (Hahn and Siebenhuner, 1982), post-collisional sediments in a rapidly subsiding shallow- intermontane basin (Helmcke and Lindenberg, 1983; Helmcke, 1985; Chonglakmani and Helmcke, 1989), mud-dominated submarine fan deposits with detached sand bodies derived mainly from active magmatic arc sources and accumulated in forearc basins above a thin continental margin (Chaodumrong, 1992), and post-collisional sediments accumulated

on continental crust in the extensional regime (Chonglakmani and Grant-Mackie, 1993).

2.3 Tertiary Sedimentary Rocks

Tertiary sedimentary rocks in the area presented in this study, the Mae Moh Group of Piyasin (1971), unconformably overlie on the Pre-Tertiary rocks and are overlain by Quaternary unconsolidated sediments. They crop out in the northeastern and northwestern portions of the study area (Fig. 4) and are made up of semi-consolidated claystone which has siltstone and sandstone interbeds. In some places, the claystone is interbedded with coal seams, especially in the Mae Moh basin (Tiyapairach, 1993). The Tertiary sedimentary strata have a total thickness of more or less 900 m. Chaodumrong and Jeumthon (1985) interpreted that the Mae Moh Group deposited in fluvial and lacustrine environments.

2.4 Quaternary Basalts and Sediments

2.4.1 Quaternary basalts

The central part of the study area is covered by a number of basalt flows. These flows form an elevated flat area of approximately 140 km^2 (Fig. 4) and are called the Mae Tha basalt. They unconformably overlie the Permo-Triassic volcanic rocks, Permian limestone and Tertiary sedimentary rocks along the southwestern margin of the Mae Moh basin. They also unconformably overlie unconsolidated Quaternary deposits in the southeastern part of the project area. Two small cones, Pha Kok Hin Foo and Pha Kok Jum Pa Dad, have been recognized due north of Ban Pa Lad. These cones generally show the opening in northern flanks of their craters (Jungyusuk and Sirinawin, 1983). The Mae Tha basalts commonly contain phenocrysts and microphenocrysts of olivine, pyroxene and spinel of which sizes are up to 2.5 mm across. They are commonly highly weathered to brownish red soil.

These basalts form the basis of discussion, in terms of occurrence, petrography, wholerock chemistry and petrogenesis, in the next chapters.

2.4.2 Quaternary Sediments

The youngest lithologic units found in the study area are semiconsolidated and unconsolidated Quaternary sediments (Mae Taeng Formation). The semiconsolidated deposits can be subdivided into two subunits: terrace gravel and colluvial deposits. The terrace gravel deposits comprise clasts (sizes 1-5 cm indiameter) of chert, shale, sandstone, limestone, volcanic rock and quartz. In addition, they have clayey sand, sandy clay and laterite interbeds. The colluvial deposits are composed of thin to thick beds of rock fragments that are mainly volcanic rocks, ferricrete, and quartz with sizes ranging from 1 to 3 cm in diameter. These deposits are covered with clayey sand and laterite. The unconsolidated sediments are recent alluvial deposits. Most are unconsolidated and compositionally similar to those of the terrace deposits.