

CHAPTER III

GEOLOGIC SETTING

Regional Geology

The regional geology of Lampang - Sop Prab area are summarized from those performed earlier by Piyasin (1971 and 1974), Bunopas and Villa (1983), and Bunopas (1992 and 1994). The area is in the central part of northern region. General geology of the regional area mainly includes sedimentary rocks of Silurian-Devonian, Permian, and Triassic. Igneous rocks as well as unconsolidated Quaternary sediments are also exposed in this area. A synoptic view of the regional geology is shown in Fig. 3.1. The sedimentary rocks are herein described in the order of ages from the oldest to the youngest below.

1. Silurian - Devonian

Rocks in Silurian-Devonian distribute in the southern region (Fig. 3.1). They are characterized by quartzite, quartzo-feldspathic schist, phyllite, chloritic phyllite, calcsilicate phyllite, and chert. These rocks have been grouped into the Donchai Group (Piyasin, 1971). The type section was located at Nam Mae Bon Stream near Ban Donchai, Amphoe Mae Tha, east Lamphun. Thickness of the sequence was not given, but is estimated later by Bunopas (1981) to be more than 1,500 m. These rocks have experienced low-grade metamorphism and their beds are mesoscopically folded.

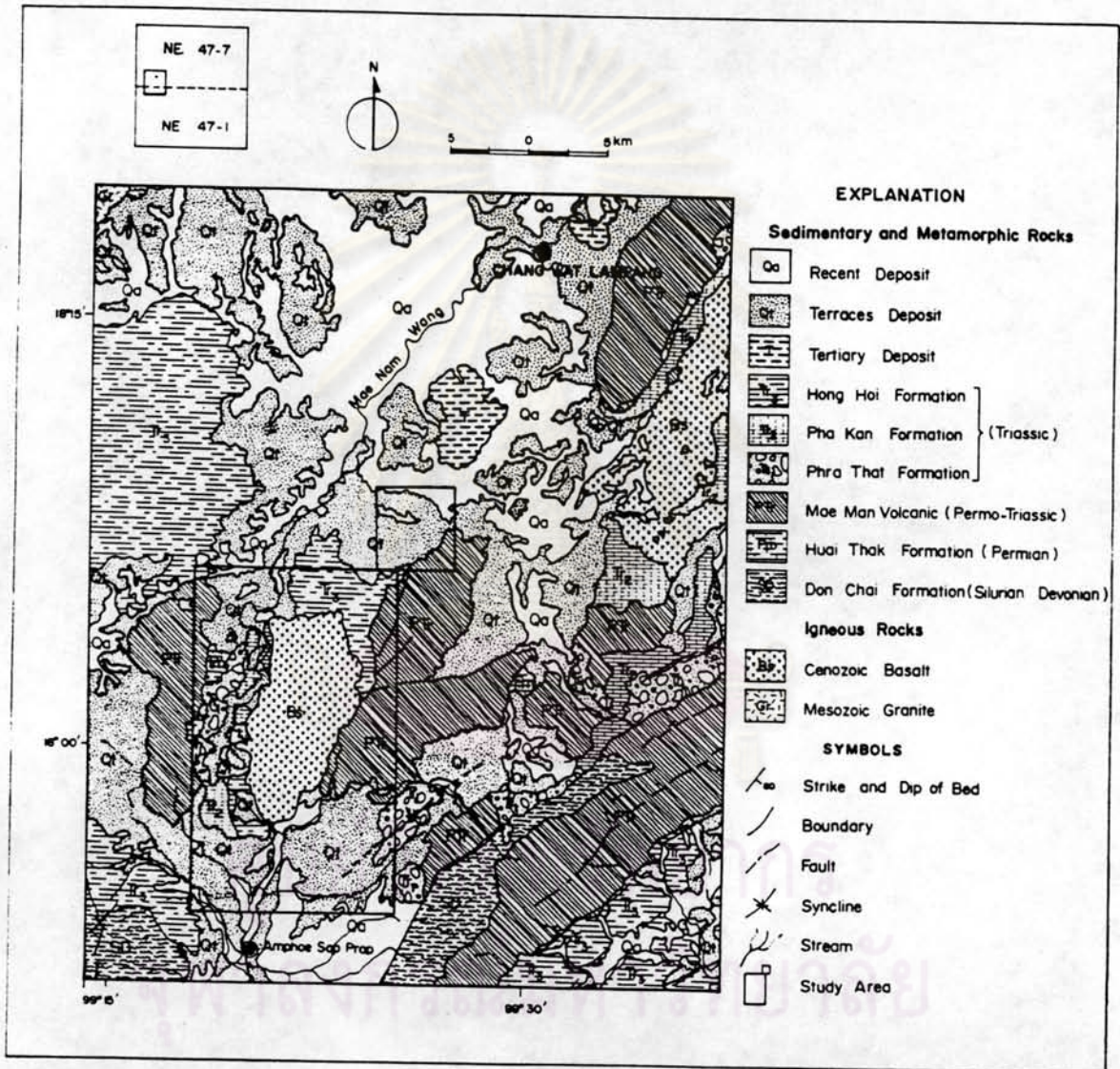


Fig.3.1. Regional geologic map of the Lampang-Sop Prab area (after Piyasin, 1971 and 1974).

2. Permian

The Permian rocks occur nearby the author's thesis area. They are relatively present as small exposures, and have been grouped into the Huai Tak Formation of the Ngao Group (Piyasin, 1971, and 1974). The Huai Tak Formation consists mainly of fossiliferous shale and thin intercalations of sandstone, limestone and intraformational conglomerate, at least 760 m and possibly up to 1,500 m thick. Twenty five Late Permian lytonid faunas from the formation are correlated with the lower Changing fauna of south China (Bunopas and Vella, 1983).

3. Permo - Triassic

The Permo-Triassic rocks in the study area comprise volcanic rocks as rhyolite, andesite, tuff and agglomerate (Piyasin, 1971, and 1974). They are collectively called as Mae Man volcanics by Charusiri et al. (1994). These rocks are unconformably underlain by clastics of the Huai Tak Formation. The Mae Man rocks have been grouped in Phare-Lampang volcanic province in northern highland volcanic rocks (Jungyusuk and Khositantont, 1992).

4. Triassic

Triassic rocks are dominantly marine sedimentary rocks. They have been grouped into the Lampang Group by Piyasin (1971). This marine Triassic sequence conformably or disconformably overlies the Permo - Triassic volcanics and Permian rocks. The Lampang Group is inferred to have been deposited in the back-arc basin (Charusiri et al., 1994). The Lampang Group comprises 5 formations, however only 3 formations

are recognized in the study area. Description of 5 formations in an ascending order are found below.

Phra That Formation : The Phra That Formation consists chiefly of epiclastic rocks including sandstones, siltstones, conglomerates, breccias, and minor limestones. These rocks are generally coarse-grained and red in color at the base, and gradually become finer-grained and green to gray in color-upwards. They are believed to have been deposited in near-shore and partly continental environments (Chonglakmani, 1983) with source materials mainly from Permo-Triassic Mae Man Group (Charusiri et al., 1994). This formation is from 100 to 840 m thick and contains bivalves, ammonoids, and brachiopods which indicate an age ranging from Upper Griesbachian (Early Triassic) to Middle Karnian (early Late Triassic).

Pha Kan Formation : This formation overlies the Phra That Formation and comprises predominantly grey limestones with minor gray to green shales and sandstones. The formation is 80 to 500 m thick and conformably underlies the Hong Hoi Formation . It contains characteristic fauna of ammonoids, bivalves, and gastropods, indicative of an age range from Upper Anisian to Upper Karnian (Chonglakmani, 1983).

Hong Hoi Formation : The Hong Hoi Formation overlies the Pha Kan Formation and is the upper formation of the Lampang Group in this study area. It consists of flysch sequence with predominantly grey to greenish grey shales, sandstones, siltstones, and conglomerates, and minor interbedded argillaceous limestones. This formation based on the macrofauna which ranges in age from Scythian (Early Triassic) to Lower Norian (Late Triassic) (Chonglakmani, 1983).

Doi Long Formation : This formation has not exposed in this thesis area , cause of its limited geographic distribution. The Doi Long Formation is 230 m thick comprising grey to light grey finely crystalline limestones, which lies between the Pha Daeng Formation and the Hong Hoi Formation. The unit contains an indeterminate fauna of bivalves, serpulid worms, brachiopods, and gastropods, however, the formation is considered to be Middle Karnian (Chonglakmani, 1983).

Pha Daeng Formation : The Pha Daeng Formation is the uppermost unit of the Lampang Group with thickness of about 500 to 600m. This formation cannot be found in the study area. It is frequently composed of well bedded red micaceous siltstone, sandstone, shale and thin coguina limestone; the basal part is a calcareous conglomerate with clasts of grey limestone, rare rhyolite and less common quartzite and slaty shale. Siltstone above the basal conglomerate can be found the fossil Hettangia (Bunopas, 1992).

5. Tertiary

Tertiary deposits expose only in few parts of this regional area. They are characterized by conglomerate, sandstone, shale, limestone, carbonaceous shale, and lignite (Piyasin, 1974). Tertiary deposits in northern Thailand always developed from intermontane basins. They frequently serve as major sources of coal and clay minerals.

6. Quaternary

Quaternary terraces and alluvial sediments are developed around the regional area. They comprise gravels, sands, silts, muds and clays. They always occur as

floodplains including Mae Nam Wang floodplain. Quaternary deposits are covered by basaltic rocks in some places.

7. Igneous Rocks

Igneous rocks of both extrusive and intrusive affinities are found in the regional area and its adjacency. These include granitic and volcanic rocks. The granitic rocks occur as small and scattered stocks and are characterized by biotite-hornblende granite, leucogranite, porphyritic granite, and pegmatite. They are inferred to be Mesozoic in age. Mostly these felsic plutonic are found in the northwestern part of this regional area.

The volcanic rocks are composed mainly of felsic and mafic rocks. The more felsic volcanic rocks have been grouped into Permo-Triassic volcanic rocks, which are described previously. Mafic volcanic rocks are characterized by basalts. They occur mostly in the thesis area and the northeastern of regional area. The basalts are dark gray, vesicular and fine-grained. Chemical compositions of the Lampang basalts denote basanites and hawaiiite (Barr and Macdonald, 1981). K/Ar ages of 0.8 ± 0.3 and 0.6 ± 0.2 Ma are reported by Sasada et al. (1987), whereas Ar/Ar age of 0.59 ± 0.05 Ma is published very recently by Sutthirat et al. (1994). Paleomagnetic studies and fission-track dating (Barr and Macdonald, 1981) have indicated the age of the Mae Tha basalt at about 0.69 or 0.95 Ma.



Geology of the Study Area

Geologic map of the study area is illustrated in Fig. 3.2. Rocks in the study area comprise mainly (meta-) sedimentary and igneous rocks. Physiographically the area form a large basin with lower altitude in the center enveloped by higher-relief terrane. Structurally, the older rock units including the Permo-Triassic and the Phra That Formation are encountered in the east, the west, and the south. As a result, the area forms a large structural syncline flanked by the old rock units. The synclinal axis is in the N-NNE direction with a low-angle plunge due north. A small anticlinal structure with similar trend is found in the southwestern part of the study area. The out pouring of basalt occurs in the middle portion of the syncline, possibly along the axis. Two other fracture systems are also recognized; one in the NW-WNW direction, and the other in the E-W direction. The former trend may be more or less related to the late Triassic felsic intrusion. Sedimentary rocks include Permian clastics and Triassic-Jurassic clastic / nonclastics. Igneous rocks comprise both intrusive and volcanic rocks, including Permo-Triassic volcanic rocks, Triassic granodiorites, and Cenozoic basalts. The details of these rocks are present below.

1. Permian metamorphic rocks

Metamorphic rocks of the Permian age are regarded as the oldest rock unit in the study area. They are generally composed principally of quartzite with some pale brown sandstone. They occur as a small, remnant but high, hills, covering an area of about 1 km² located at the north of Mae Than reservoir , Ban Mae Kua. These rocks were cut by NE- and NW-trending faults. The occurrence of metamorphosed sandstone leads Charoenprawat et al. (1986) to assign the rock sequence older than the others in

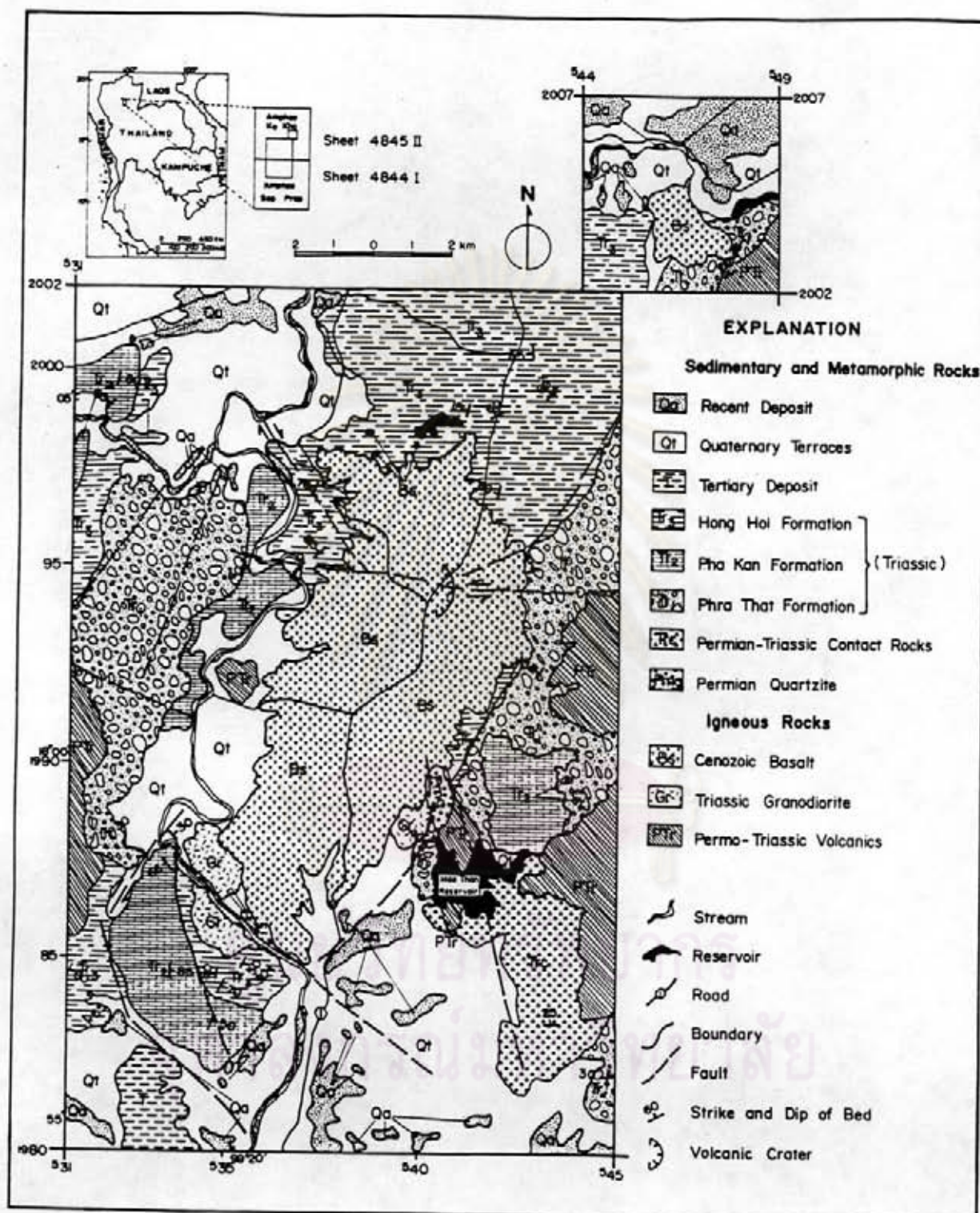


Fig.3.2. Geologic map of the study area (modified after Charoenprawat et al., 1986), showing the distribution of the Nam Cho basalt and the Sop Prab-Ko Kha basalt.

the study area. The attitude of bedding is strikes N-S and dips at 60° to W. The estimated thickness is not less than 100 m.

2. Permo-Triassic rocks

The Permo-Triassic volcanics comprise rhyolites, andesites, tuffs, and agglomerates, they generally form as high, steep-slope hills, and can be found in the eastern and western edges of the area. Typical locations include Doi Ton, Doi Mon Khamin, and Doi Lak Kai. Rhyolites are characterized by pale gray to pink, fine-grained rocks and containing quartz and plagioclase crystals. Andesites are always green to deep green, fine-grained rocks, with abundant phenocrysts of plagioclase, hornblende, biotite, and pyrite. Tuffs and agglomerates are also associated with rhyolites and andesites, which they cannot be clearly differentiated. In some places, the rocks show distinctive layers with the attitude of 160 / 70 and are difficult to distinguish from the overlying Phra That rock unit.

3. Upper Permian-Lower Triassic contact rocks

Contact rocks contain association of igneous, sedimentary, and metamorphic rocks. Those comprise quartzites, rhyolites, sandstones, shales, and conglomerates. Geographically, they always show as small hills continually distributed in southeast of Mae Than reservoir. The average thickness of this unit is 300 m. The attitude of bedding varies in strikes from N5°W to N90°E and dips from 20° to 25° due NE.

4. Triassic sedimentary rocks

Triassic rocks are characterized by clastic and nonclastic marine sedimentary rocks of the Lampang Group, including Phra That, Pha Kan, and Hong Hoi Formations. They widely distribute in this area. Total thickness is about 800 m.

The Phra That Formation is the lowermost and oldest part of the Lampang Group in Lower Triassic age. Typical locations comprise Doi Ton, Doi Ngoen, and Doi Kaeo in the western and eastern ranges. Thickness is approximately 300 m. These rocks commonly consist of sandstones, shales, siltstones, agglomerates, and tuffaceous sandstones, with reddish brown and gray. The conglomerates in the lowest part comprise gravels of cherts, andesites, and rhyolites with silica cements.

These conglomerates generally show poorly sorting, and gravels often occur as angular to subround, with size of less than 16 cm to more than 25cm. The upper rocks are brown to reddish brown sandstone alternate with siltstones and shales, limestone lens and scattered tuffs may sometime penetrate. Their attitude generally strike N10° E to N70°E and dip 15°-85°SE, that rests unconformably on the Permo-Triassic rocks. These rocks occur as hills, mostly present in the east and west of area.

The Pha Kan Formation is characterized by limestone, massive to well-bedded, light gray to dark gray, with interbedded black shales. They are mainly in N-S to N15° W trending with 70°-85° dip. These rocks occur as moderate high hill in the west and the east. The average thickness of this unit is 100 m. The Pha Kan Formation is defined as Middle Triassic.

The Hong Hoi Formation is composed of greenish grey to light grey shales, with interbedded sandstones and dark gray limestone lens. Sandstones are characterized by fine to medium grained size, with high sphericity, well roundness, and well sorting. They are in N10°W to N70°W trend with 60°-80° dip. The rocks also distribute in the northern and western parts, which typical locations comprise Huai Rai, Huai Na Saeng, and Doi Chadi. This unit is about 400 m thick. They are partially covered by basalts and Quaternary unconsolidated sediments.

5. Tertiary sedimentary rocks

Tertiary sedimentary rocks contain sandstones, shales, conglomerates, and limestone. They may occur as semiconsolidated deposits in some parts. In the study area, the Tertiary deposits, especially white claystone, can be found in the south. Tertiary deposits, containing lignite and ball clay are economically exposed in the adjacent area.

6. Quaternary sediments

The Quaternary sediments comprise unconsolidated and semiconsolidated sediments. The semiconsolidated deposits are mainly characterized by terrace sediments comprising clay, sand, and gravel in the moderately high area. These gravels include generally shale, rhyolite, andesite, chert, granite, and quartz, etc. The unconsolidated sediments are frequently characterized by recent deposits, as alluviums and colluviums.

7. Granodiorites

The granodiorites are found as small, isolated stocks in the south, such as both sides of Mae Nam Wang and north of Mae Than reservoir. They are generally characterized by porphyritic, coarse-grained, hornblende-biotite affinity. Feldspar phenocrysts are mostly plagioclase and range from 1 to 2 cm. These granodiorites may probably occur in Upper Triassic (to Cretaceous) periods. Quartz veins (up to 20cm thick) are also found in and around the granitic rocks.

8. Basalts

Basalts widely distribute in the study area and its adjacency. They are classified as olivine basalts by field investigation. Mostly the basalts show a distinct volcanic crater (Fig. 3.2). The basalts always contain phenocrysts of olivine, pyroxene and spinel, with the average size of 0.2 to 2 cm. Basalts frequently show vesicular texture, exfoliation and columnar - liked jointings. They are classified to be Late Cenozoic in age. In the study area, basalts can be geographically divided into 2 parts as the Nam Cho basalt (north basalt) and the Sop Prab-Ko Kha basalt (south basalt). In the field, the basalts are found as volcanic flows lying over the Triassic rock sequence (Fig. 3.3) and some are found as gravel deposits to highly weathered flows (Figs. 3.4, 3.5, and 3.6) lying on tops of unconsolidated Quaternary deposits. These evidences imply that these basaltic flows are quite young (see the details in the discussion chapter). Petrographic descriptions of these rocks are described in the next chapter.

Regional Structural Geology

The regional geological structures generally comprise several small sub-basins within the major Lampang basin. These sub-basins are significantly controlled by faults and unconformity. The former are of normal and strike-slip movement. These faults align in at least 2 directions, as NE and NW directions. The NE-trending fault may have occurred before the NW-trending fault. Many joints and fractures frequently align in NW-, E-, and NE-directions, those are often associated with major fault zones which may have occurred during Upper Permian to Upper Triassic. Foldings (Fig. 3.7) are also present, including inclined, recumbent and overturned folds, with NE-SW folding axis. These folds frequently overprinted the Triassic rocks, and can be found at both sides of Mae Nam Wang and in the eastern part of the study area. The foldings may have formed contemporaneously with faultings.

Sapphire Occurrences

The gem exploration project launched by DMR was planned to cover basalts in this area. At least 15 pittings were designed in the north basaltic area, and 65 pittings in the south basaltic area. Sapphires were discovered in 4 pittings in the north, and 12 pittings in the south (Fig. 3.8). Occurrences of sapphires always are along stream and residual deposits in both basaltic areas. The sapphire bearing-layers of the Nam Cho (northern) basalt are frequently present as grayish brown, yellowish brown, moderate yellowish brown, and dark yellowish brown in color, whereas that of the Sop Prab-Ko Kha (southern) basalt is always characterized by moderate brown to grayish black, dusky yellowish brown, brownish gray, grayish black, and brownish black.



Fig.3.3. Volcanic flows of the Sop Prab-Ko Kha basalt (top half) lying on the Triassic rock sequence (bottom half).

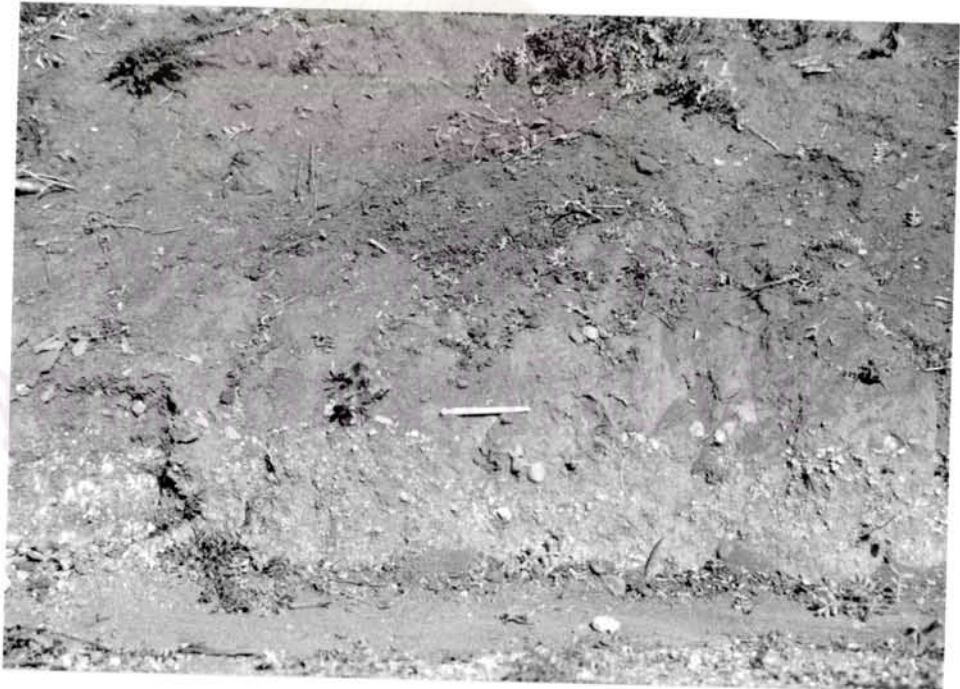


Fig.3.4. The thick basaltic soil covering gravel bed around the south edge of the Sop Prab-Ko Kha basaltic area (grid reference 362854).





Fig.3.5. Residual weathered basalts overlies gravel deposit of the Triassic rocks at the west edge of the Sop Prab-Ko Kha basaltic area (grid reference 357914).



Fig.3.6. Characteristic of gravels of the old Mae Nam Wang River at the south edge of the Sop Prab-Ko Kha basaltic area nearby the recent Mae Nam Wang River (grid reference 371856).



Fig.3.7. Foldings of the Hong Hoi Formation showing NE-SW fold axis.

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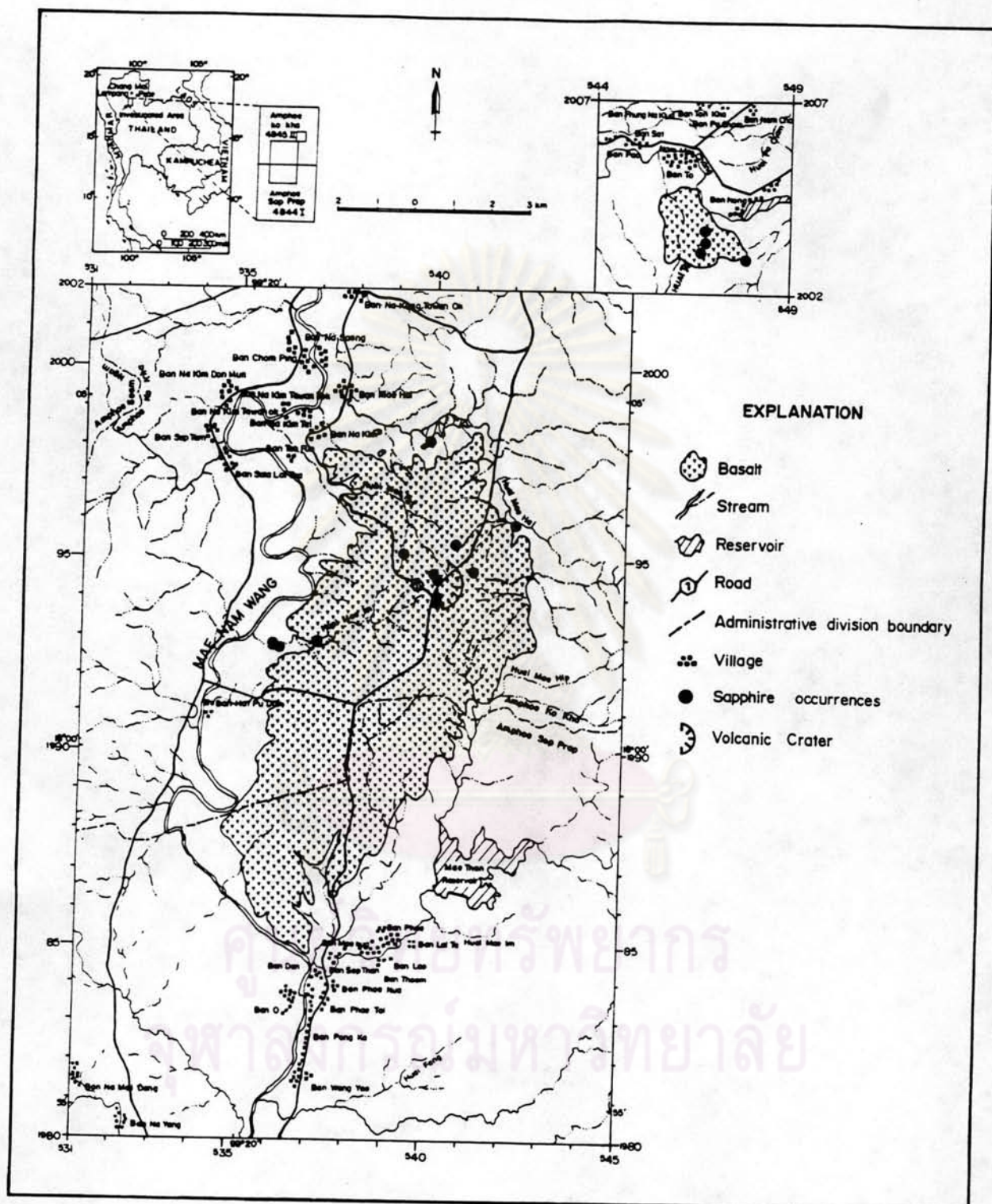


Fig.3.8. Map showing the aerial extent of basalts and locations of sapphire occurrences in the study area (after Suthirat et al., 1995).

1. Nam Cho Basaltic Area

Sapphires generally disperse in layers of gravel, sand, and clay. Most of gravels are typically basalt, and moderately andesite, rhyolite, sandstone, and tuff. Sapphire frequently occurs in the level of 0-2.20 m depth. Gem bearing - layer ranges in thickness from 0.65 to 1.3 m. Sapphires in this terrane were found along Huai Khi, Huai Ta Sua, Huai Teen Cha, Huai Hua Ma, and Huai Khi Tud, and some are located in Ban Nong Tambon Nam Cho, Amphoe Mae Tha. These sapphires are characterized by sky - blue, greenish sky - blue, blue, and brownish blue sapphires. They generally show angular - subangular shapes, with transparent - translucent properties. Their average grain size ranges from 1.0 to 5.0 mm. Associated minerals comprise pyroxene, spinel, and iron oxide minerals. Average grain size of these minerals are 0.5 to 1 cm, though they invariably range from 0.2 to 7.0 cm. They also form subangular shapes, which are relatively larger than the southern area.

2. Sop Prab - Ko Kha Basaltic Area

Sapphires in this terrane disperse around a volcanic crater, that is locally called "Lung Thurn". They occur in the Huai Mae Pad, Huai Mae Heap, and Huai Mae Hi, Ban Tao Poon, and Ban Mae Hi, Tambon Noosing, Amphoe Ko Kha. Sapphire frequently occurs at the level of 1.5 m depth, with 0.2 to 0.8 m thick. The layer generally comprises gravels, sands, and weathered basalts. Sapphires of this terrane are characterized by sky-blue, brownish sky-blue, blue and brown star sapphires. They range from 2.5 to 6 mm in size, and generally occur as angular to subangular shapes, with transparent to translucent grains. Associated minerals frequently contain olivine, spinel, pyroxene, iron oxide, and rare zircon. They generally range from 1.0 to 6.0 mm in size, with 3.0 to 5.0 mm of average grain size.