CHAPTER II

REGIONAL GEOLOGIC SETTING

Introduction

The mountain ranges and major rivers in Kanchanaburi province are mostly lied in the NW-SE direction. They are mainly controlled by regional geology and structures. The major structure of the entire study is parallel to the Three Pagoda Fault Zone. In this research, for more convenience, the Three-Pagoda Fault Zone is herein called TPF. The systematic geological investigation within in this research area was performed in the year 1976 by staff of Department of Mineral Resources (Siribhakdi et al., 1976). Three geological maps have been used as fundamental maps in this research, including as Changwat Suphan Buri (ND47-7), Tavoy (ND47-6) and YE (ND47-2). Geological, structural, and tectonic frameworks of western Thailand covering the area under investigation, has been recently reviewed by Raksaskulwong (1997).

Geological setting

Figure 2.1 shows generalized geology of western Thailand. There are several rock units in Kanchanaburi. Whose ages range from Precambrian to Quaternary. Due to the fact that the author's research study is not focused into detailed geology within the area of investigation, therefore only a brief geology and some observation obtained from satellite image data are described .

Precambrian

The Precambrian rocks of Kanchanaburi are paragneiss, micaschist, calc-silicate and marble exposing in a few restricted areas along the TPF. The rocks of this age are designated as Thabsila gneiss (Bunopas, 1976). The Thabsila gneiss has been more or less uniformly metamorphosed dynamothermally to amphibolite facies (Dheeradilok, 1975). Gneiss lies beside the Cambrian rocks that are metamorphosed to a much lower grade, never more than green schist facies (Bunopas, 1987). Although the relation of the Thabsila with the Cambrian rocks are obscured by faulting are recognized from remote-sensing data and the age of the gneiss has not been yet isotopically determined, the metamorphic unconformity clearly indicates that the Thabsila gneiss is relatively older than the Cambrian rocks of which their ages are confirmed by Upper Cambrian trilobites. In the Landsat image, the Precambrian rocks show low topography with gentle slope and have dendritic patterns almost similar to granitic rocks.

Cambrian

The Cambrian rocks of the study area include quartzite, phyllite, metamorphosed sandstone and meta-siltstone. Such characteristics of rocks give rise to being resistant to erosion and forming the sharp- edge ridges along eastern and western sides of the Khwae Yai River, as can be clearly seen in both Landsat and JERS images. The name Chao Nen Quartzite was designated for the rocks occurring in Cambrian by Bunopas (1976). The quartzite - phyllite sequence of the Chao Nen Quartzite dips at varying angles from moderate to steep and locally overturned. Some exposures exhibit mesoscopic sharp chevron folds.

Ordovician

The name Thung Song Group (Javanaphet, 1969) has been officially applied to all Ordovician limestones in Thailand. In the study area, most of the rocks belonging to Ordovician age are mainly argillaceous to siliceous limestones. These limestones have been designated as the Tha Manao Formation (Bunopas, 1981) in Kanchanaburi. Remote sensing data indicate that the Ordovician carbonates have not formed karstic tower, due mainly to the impurities in carbonates, making them quite contrast to those of Permian (see below). Wongwanich and Burrett (1983) pointed out that the Upper Ordovician Ibexian-age carbonates outcropping around the Srinagarind dam site in Kanchanaburi Province consist of largely bioclastic limestones and interbedded mudstone. Because of lacking evidence of peritidal condition in the area, they concluded that the rocks were probably deposited in relatively deep subtidal conditions, in contrast to the peritidal carbonate deposited around the Song Tho lead-zinc mine (close to Myanmar border) and at Khao Tham (north of Kanchanaburi city).

Silurian - Devonian

The type section of Silurian - Devonian Bo Phloi Formation (Bunopas, 1981), is at two isolated hills, south of Bo Phloi District. Lower part of the sequence consists of massive quartzite and interbedded with layer of phyllite. Intermediate part, the rocks are tuffaceous sandstone, tuffaceous shale, and chert interbeds, overlain by shale. Rocks of the upper part of the sequence are composed largely of thinly bedded and recrystallised limestones. In some locations, the sequence conformably overlies the Ordovician Thung Song Limestones. In Thong Pha Phum, to the north of the area, the Silurian sequence consists of black shale, siltstone, and thin-bedded nodular limestone. Late Silurian conodonts at its base and continuity into the Devonian (Hagen and Kemper,1976). Consequently, there is no lithologic boundary between the

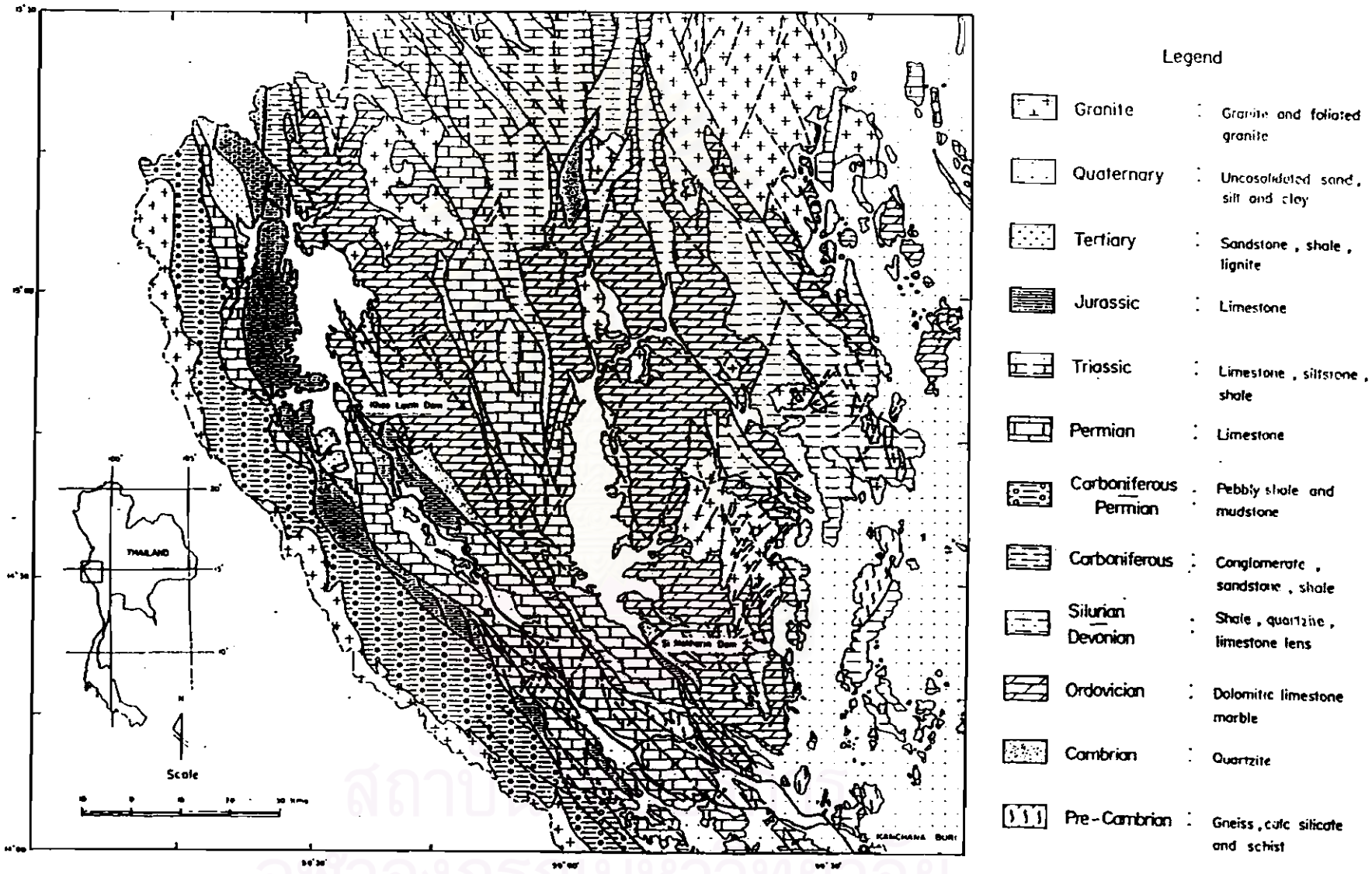

Figure 2.1 Gological map of western Thailand (Raksaskulwong, 1997)

Silurian and the Devonian (Fontaine and Suteethorn, 1988). Remote sensing information indicates that landforms occupied by Middle Paleozoic rocks are mostly moderate to gentle slope with rather high relief due to the durability of the rocks.

Carboniferous

Carboniferous rocks in this region are collectively called as the Thong Pha Phum Group (Bunopas, 1981) and is designated to represent the succession lying between the Ordovician Thung Song Limestone and Permian Ratburi Limestone. The Thong Pha Phum Group consists chiefly of sandy marl, black shale and calcareous siltstone. These rocks which are associated with Devonian to Triassic rocks, are well exposed in the western part of Khao Leam reservoir. Due to their indurability, they can be observed in satellite images as relatively low hilly terrain. Both Landsat and field information reveals that these clastic-dominated until form rather low topography with gentle slope and low relief.

Permian

There is no type section at the type locality (Ratburi Province), but the name Ratburi Limestone (Brown and Buravas, 1951) and Ratburi Group (Javanaphet, 1969) have been applied throughout Thailand for limestones and associated clastic rocks of Permian age. Exposures in Ratburi Province are isolate hills protruding Quaternary alluvial covers; and at no place provide a complete section of the Ratburi Group. Permian rocks in Kanchanaburi can be divided into 3 types as Khao Muang Khrut sandstone, Sai Yok Formation and Tha Madua sandstones (Bunopas, 1977). Khao Muang Khrut sandstones are composed largely of calcareous sandstone containing brachiopods, pelecypods, bryozoans and corals. Sai Yok Formation consist of massive and bedded limestone containing fusulines, brachiopods, pelecypods and bryozoans. Red sandstone and white quartz sandstone are quite abundant and form thickly bedded unit assigned as the Tha Madua sandstones. Remote sensing information clearly indicate that the Sai Yok Limestones form a few ridges of outstanding karstic towers. They appear to align following the regional structure in the NW trend, almost parallel the main TPF.

Triassic

Triassic rocks are discontinuously exposed along the TPF and are designated as the Chong Khap Formation (Bunopas, 1981). The base of the formation has not been observed. However, all known contacts with older rocks

are faults and are certainly recognized very well in the satellite images. The lower of the succession comprises grey siltstone and shale with sandstone interbedded. At Ban Chong Khap and Ban Tha Thong Mon (in the middle parts of the study region), bivalve fossils - Posidonia, Halobia and Daonella- were identified as middle Triassic in age (Bunopas, 1981). The middle part of the formation consists mainly of siltstone, shale and fine-grained sandstone with local thin-bedded limestones. The upper part is composed chiefly of bedded limestone with abundant chert nodules. Most of the rocks have their attitude (of bedding) in the northwest. Field and remote-sensing information indicate that the Triassic sequences form in long and narrow areas following the regional strike of NW-SE direction.

Jurassic

Bunopas (1981) separated Jurassic rocks in western Thailand into 2 formations namely Kaeng Raboet Formation of continental deposits and Diso Limestone of marine deposits. Very recently, the Jurassic rocks in the western and northwestern parts of Thailand are extensively studied in details on the aspects of succession, paeloecology and paleoenvironment by Meesok and Grant-Mackie(1997). The warm and shallow water environment is suggested for the rocks in the study area. The lower part of the Kaeng Robeot Formation is composed of conglomerate and some red coarse-grained sandstone lens. The middle part of the formation comprises the alternation between conglomerate and sandstone. The upper part of the unit is composed of red shale and intercalated red cross-bedded sandstone. The relation between this formation and the underlying rocks is often the fault contact. Clasts in the Kaeng Roboet conglomerate, including limestone with Permian fossils, indicate rapid erosion of the adjacent older rocks. The Diso Limestone invariably overlies conglomerates and red clastics of the Kaeng Raboet formation. Limestone displays a very shallow marine facies. In addition, the age of the Jurassic rocks in Kanchanaburi are also confirmed new foraminifera genera by Kemper (1976). The Jurassic rocks as observed in satellite images are rather flat terrain with low-lying hills. Good exposures are at Amphoe Sai Yok and Amphoe Thong Pha Phum in the middle part of the study area.

Tertiary

Small and narrow Tertiary basins in Kanchanaburi province align in the NW- SE direction, which are mostly parallel to the TPF. In this study area, Tertiary basins include Ban Rai and Mae Chan basins (Siribhakdi, 1976). Ban Rai basin (about 2 x 8 km) is located at Khao Laem Reservoir in the northern part of the study area , and Mae Chan basin (about 2 x 8 km) is at Amphoe

Sangkhla Buri in the western most part of the area. Most Tertiary sediments exhibit semi-consolidate nature and are mainly conglomerate, sandstone, siltstone and mudstone. They are well recognized in satellite images by relatively low-relief and gentle-slope topography as compared with those of the older rocks.

Quaternary

Quaternary deposits are terrace, colluvial and alluvial deposits. Alluvial deposits can be found along the river, i.e. Khwae Noi and Kwae Yai River, Huai Bong Ti, etc. Terrace and colluvial deposits can be recognized along the rivers and close to the mountain flanks, respectively. This unit is composed largely of gravel, sand, silt, clay and semi-consolidated to unconsolidated bed. Like the Tertiary deposits, the Quaternary sediments distribute as long and narrow strands in the NW - SE direction along the river trends. Satellite image data advocate that they are flat-lying areas with some slope angles for the colluviums controlled in a large extent by the TPF.

Igneous rocks

Granite

Granite rocks are quite common in the western part of Kanchanaburi province close to the Thai-Myanmar border. Although the majority of the granites are hornblende-biotite granites (Siribhakdi et al., 1976) whose probable age is Cretaceous. There is also Sn-W mineralization around the Pilok mines and prospects along the Thailand-Myanmar border. The ages of the deposit as well as the associated muscovite granites are assigned as 70-77 Ma by Ar/Ar method (Charusiri, 1989). Most deposits are fracture-controlled and they are cross-cut by mostly mineralized pegmatitic and quartz veins, veinlets and stock works. In satellite image, the granites knob-like terrains are characterized by dentritic stream pattern with rather high slopes and relief.

Basalt

Basalts occur as small, semi-circular-shaped area in the study region. They are found at Bo Ploi District, in western part of the area survey, so they are collectively called Bo Ploi Basalt (Barr and MacDonald,1978). Following Choowong (1996), the Bo Phloi Basalt contains microlite of plagioclase in the groundmass and layer crystals of olivine, pyroxene, spinel and xenolith of gneiss. This basalt has also been postulated to be the main source of sapphire in this area. The ages of Bo Phloi Basalt are 3.14 $\pm$ 0.17 Ma (K-Ar

method, Barr and Macdonald, 1978), and 4.17 ± 0.11 Ma ($^{40}Ar/^{39}Ar$ method, Sutthirat et al., 1994). Rather flats with somewhat gently slopes are recognized from the remote-sensing images.

Structural Setting

Folding

Structures of the study area are quite intricate. Folds are recognized in many places both from field and image data. Most fold axes are in the NW-SE trend (Bunopas, 1976; Siribhakdi et al., 1976, Sripongpan and Kojedee, 1987; Kemlek and Cheamton, 1989). Fold structures can be found in several rocks and many characters such as syncline and anticline folds which are the general major folds can discovered in the Permian limestone in the southeast investigation area (Bunopas, 1976) and Ordovician in Khao Leam area (Siribhakdi,1976). Overturned fold is observed in the Permian limestone located in the eastern part of Lin Tin area (Siribhakdi, 1976). Field and remote-sensing information reveal that in Devonian-Ordovician, there are tight fold and recumbent fold in the western part of Kanchanaburi and parallel with Three Pagoda Fault

Faulting

Chuaviroj (1991) reviewed geotectonics of Thailand and mentioned several major faults in Thailand. In his note, major faults in Kanchanaburi province include Srisawat and Three Pagoda (TPF) Fault Zones. The mainly N-trending Srisawat Fault Zone with the curvilinear pattern at both ends consists of several fault sets, but is mainly situated between Mae Ping and TPF Fault Zones. One of the Srisawat Fault zone commences from Amphoe Srisawat and northern part of Amphoe Bo Phoi, Kanchanaburi province. This fault crosses the Khwae Yai River in the NW-trending and continues to extend to Myanmar. The fault zone is deviated following the Mae Ping Fault Zone in the north by cutting many kinds of rocks ranging in age from Paleozoic to Cenozoic. This fault zone length is about 200 km (Nutalaya et al., 1985). Detailed description on the TPF is discussed in the Chapter III .

Regional Tectonic Setting

Thailand comprises two major continental blocks, the Shan-Thai and the Indochina terranes (Bunopas, 1981). An intervening band between the two blocks (Fig. 2.2) is the Thai- Malay Mobile Belt (Ridd, 1980; Hahn et al., 1986) or the so-called Paleotethyan oceanic crust by Charusiri et al. (1997a), Charusiri et al. (1999a), and Tulyatid & Charusiri (1999). The Shan-Thai Block includes eastern Myanmar, western Thailand and western peninsular Malaysia. This block

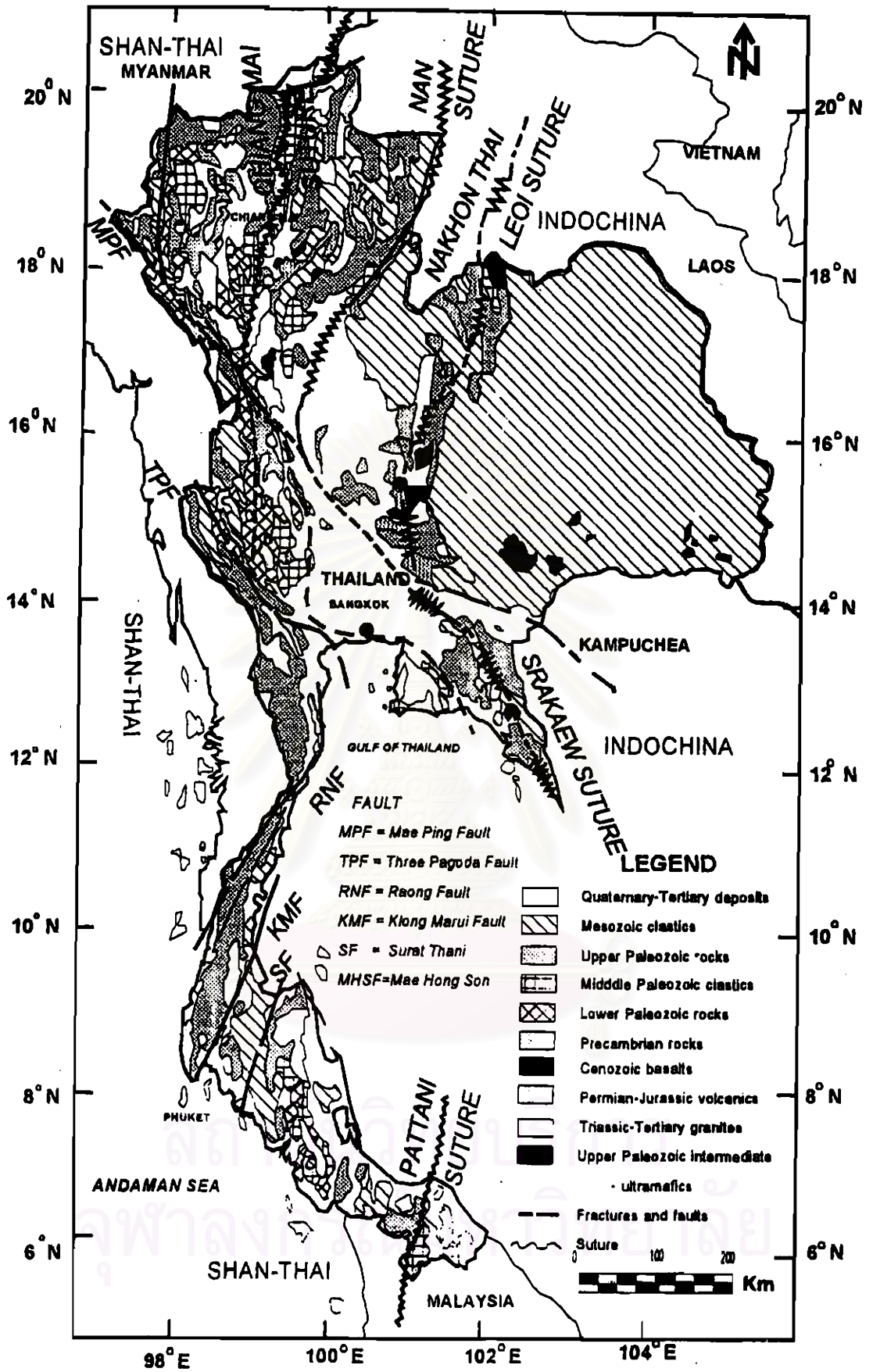

Figure 2.2 Geologic map of Thailand showing major tectonic blocks (Charusiri et al., 1999a)

consists of inferred Precambrian high-grade metamorphic rocks of gneiss, schist, calc-silicate and marble overlain by folded Paleozoic and Mesozoic rocks (Bunopas, 1981; Fontaine, 1985). The Indochina Block in northeastern Thailand is composed mainly of gently folded Mesozoic continental deposits of the Khorat Group, Permian carbonate platform associated with deep water clastic facies (Wielchowsky and Young, 1985) and older Paleozoic rocks. The Paleotethyan oceanic crust is a structurally complex area, with folding and overthrusting towards the east (Bunopas, 1981). The belt extends from Northern Thailand, Central Thailand through the Gulf of Thailand. The area is characterized by strong volcanism (mainly calc-alkaline volcanic rocks) during Late Permian to Middle Triassic and marked the boundaries with Shan-Thai to the west and Indochina to the east. It is interpreted as a collision belt on the suture zones between the Shan-Thai and the Indochina Blocks (Bunopas, 1981; Mitchell, 1981; Hahn et al., 1986). Mantanajit (1997) explained tectonics in Cenozoic that most of tectonic features in Thailand (and Southeast Asia) are mainly the consequence of the India-Eurasia collision (Monar and Tapponier,1975: Tapponier et al., 1982; 1986). Several strike-slip faults were reactivated successively as Indian terrain moving northward against Eurasia terrain and thus, the Red River Fault was activated. Consequently, the Southeast Asian crustal block was rotated clockwise and then extruded several hundreds kilometers southeastward (Achache et al., 1983; Lin and Watts, 1988). The extrusion and rotation of the Southeast Asian crustal block resulted in a series of extensional basins extending from the Gulf of Thailand (Charusiri et al., 1999b)to the south China Sea (Harder, 1991). Stratigraphic records in the region indicate that normal block-faulting began in the Early Oligocene. In Thailand, three different fault systems can be distinguished: (1) N-S normal and thrust faults, (2) NW-trending strike-slip faults, and (3) NE to NNE - trending strike slip faults . The NW-trending fault zones include the Mae Ping and TPF while the NE-NNE trending ones are the Uttaradit, Ranong and Khlong Marui Faults (Polachan, 1988). It is important to note that the TPF is located within the Shan-Thai block. Fig. 2.3 illustrates 4 stages of tectonic evolution of Thailand (Charusiri et al., 1997a)

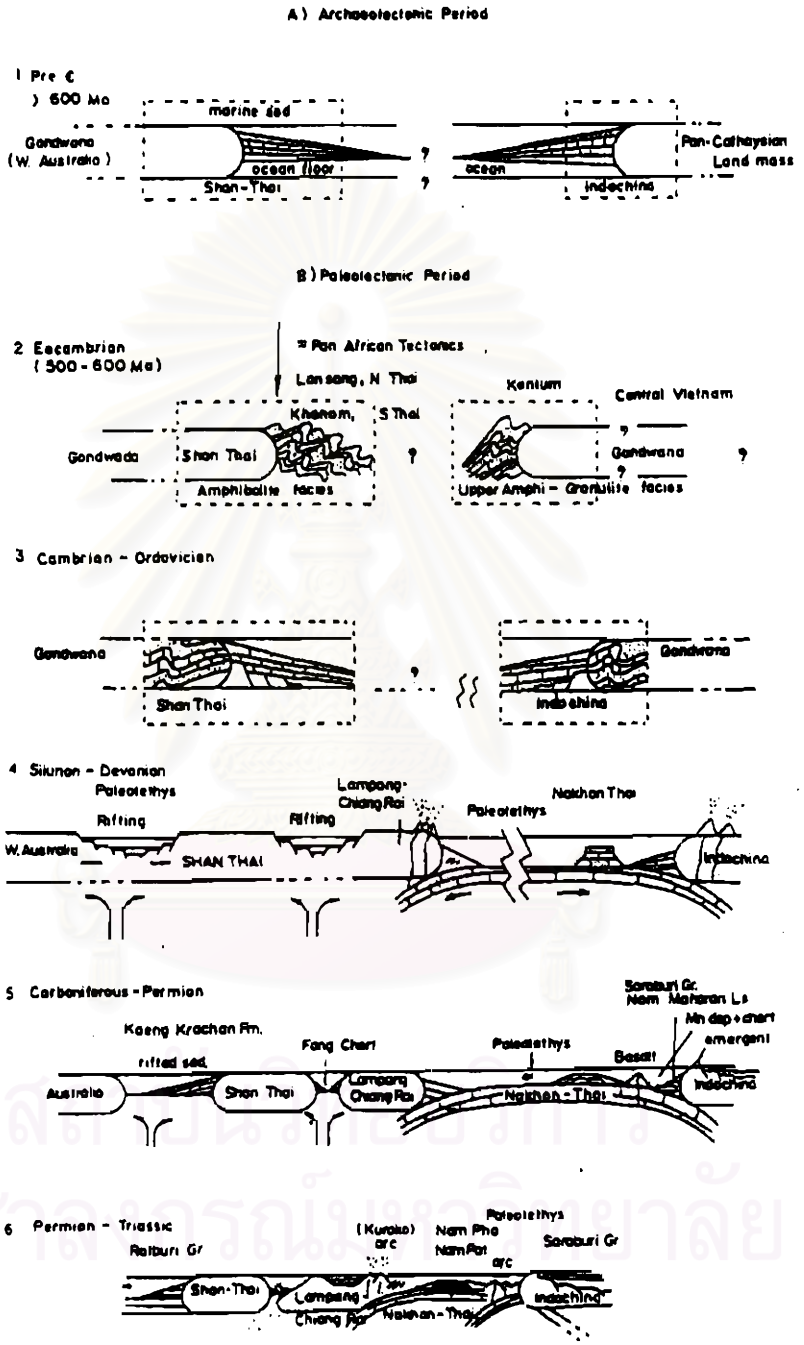

Figure 2.3 Tectonic evolution of Thailand during archaeotectonic, paleotectonic, mesotectonic, and neuvotectonic stages (Charusiri et al, 1997a).

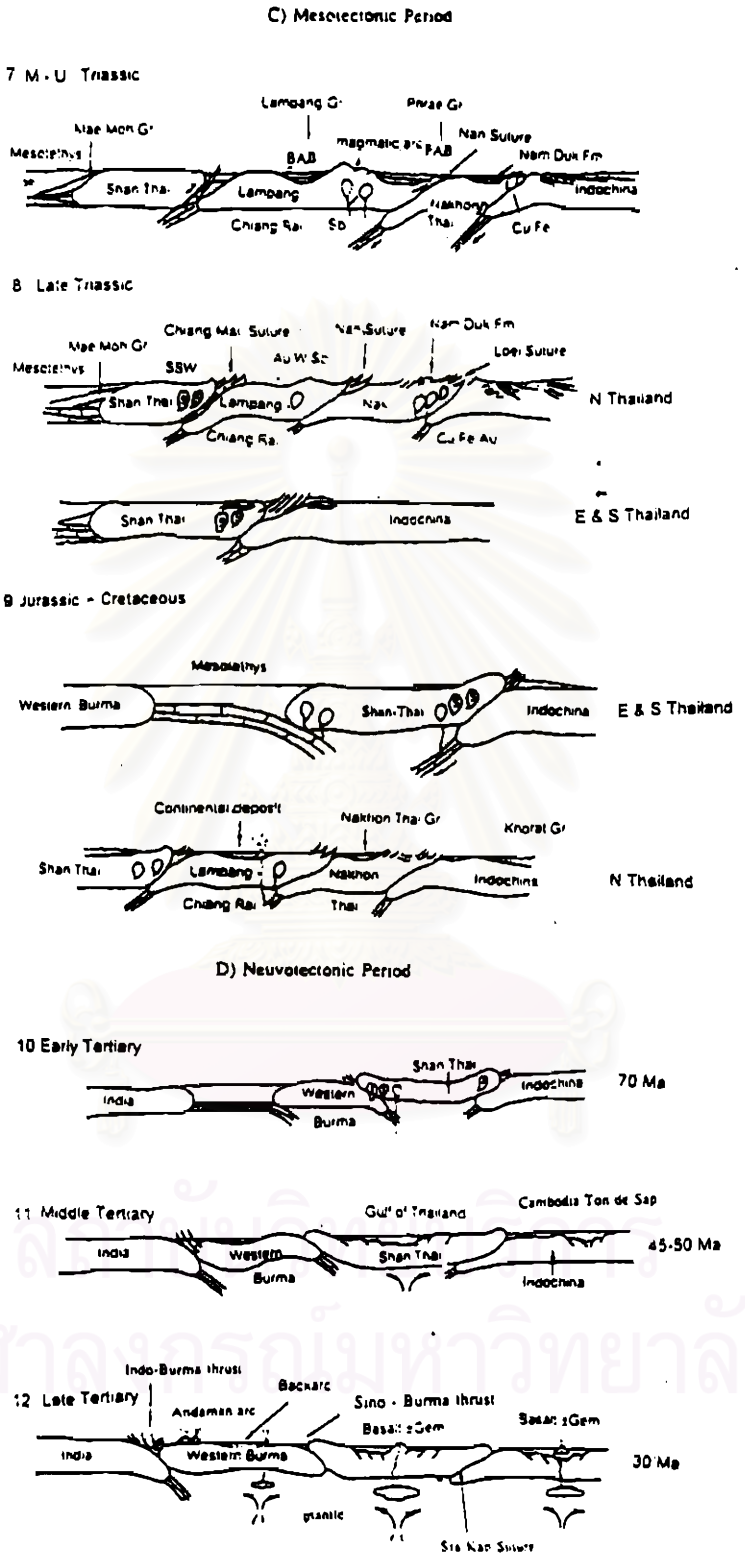

Figure 2.3 (cont.)