



CHAPTER II

REGIONAL GEOLOGY AND MARINE TRIASSIC ROCKS IN THAILAND

Study on Marine Triassic rocks sequence in Thailand has been considered by several works (Braun and Jordan, 1976; Bunopas, 1981; Chaodumrong, 1992; Chonglakmani, 1999; Meesook et al., 2002, 2005; Srinak et al., 2002). The details of regional geology and marine Triassic rocks in Thailand have been explained in this chapter.

2.1 Regional Geology

Mainland Thailand consists of two principal continental blocks: the western Shan-Thai Block (Sibumasu or Sinoburmalaya) and eastern Indochina Block. The boundary between these two blocks is may be used to be the Nan-Uttradit Suture, represented by remnants of paleo-oceanic sediments and arcs, between the Shan-Thai Block and Indochina Block (Bunopas, 1981).

The Shan-Thai Block is an elongate continental block trending north-south with a Precambrian basement. The Lower and Middle Paleozoic sequences of this block are Cambrian and Ordovician siliciclastics and carbonate rocks, and Silurian and Devonian fine-grained clastics and limestones. The Upper Paleozoic sequences of this block are characterized by Upper Carboniferous to Lower Permian glacio-marine diamictite and Lower Permian cool-water faunas. Geological and paleontological evidence suggest that this block originated in northwest Australia Gondwanaland. These continental blocks were removed from Gondwanaland after Early Permian time and collided with Indochina in Late Triassic, closing of the Paleotethys Ocean. The Indochina Block is also an elongate stable block, consisting mainly of Precambrian rocks and Paleozoic shallow marine strata with Mesozoic continental deposits. Paleozoic and Mesozoic faunas and floras of this block are confirmed to be of warm climate type (Metcalf 1988).

Bunopas (1992) recognized seven longitudinal stratigraphic belts, BS-1 to BS-5, and BI-6 to BI-7 from west to east, the first five of which cover the Shan-Thai Block in Thailand. The study area is probably within BS-2. Ueno (1999) established a new

tectonostratigraphic scheme, mainly for Thailand, based on extensive lithostratigraphic and paleontologic investigations. Ueno (1999) subdivided Thailand into four tectonostratigraphic units, the Sibumasu Block (Shan-Thai), the Inthanon Zone, the Sukhothai Zone, and the Indochina Block, from west to east, which are separated by the Mae Yuam Fault, the "Cryptic" suture Chiang Rai Line, and Nan-Uttaradit Suture, respectively (Figure 2.1). These divisions extend northward to western Yunnan, China. The investigated area in Mae Sot-Prop Phra may belong to the Sibumasu Block of Ueno (1999).

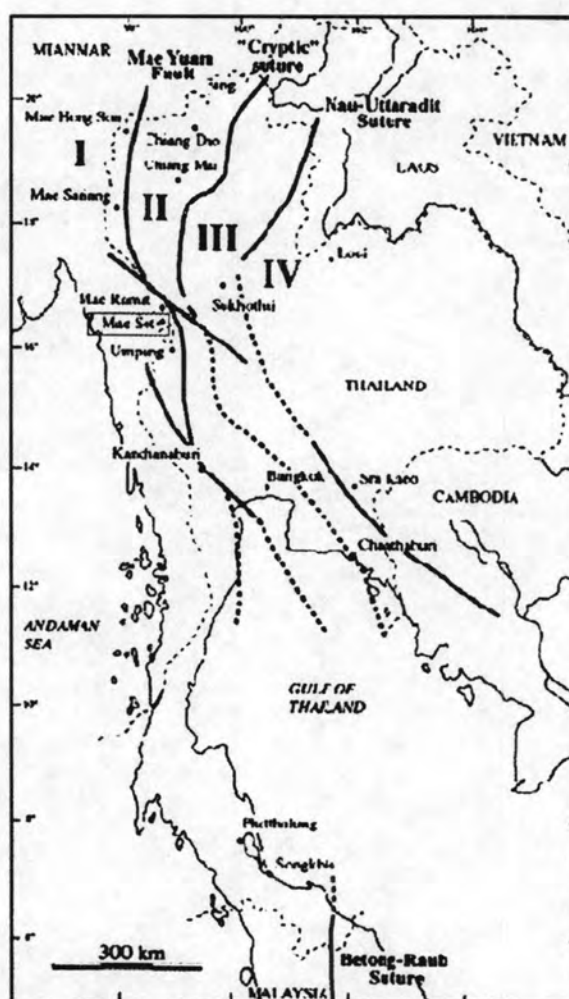


Figure 2.1 Index map showing the tectonic subdivision of mainland Thailand and the study area (Mae Sot-Phop Phra). I: Sibumasu Block, II: Inthanon Zone, III: Sukhothai Zone, IV: Indochina Block (after Ueno, 1999).

2.2 Marine Triassic rocks in Thailand

Marine Triassic sedimentary rocks are mainly distributed in the northern, western, eastern, and southern parts of Thailand (Figure 2.2). The marine Triassic sediments are distributed in three sedimentary basins, the Mae Hong Son-Kanchanaburi Basin in the northwest and west, the Lampang-Phrae Basin in the central north, and the Songkhla Basin in the south (Chonglakmani and Grant-Mackie, 1993).

2.2.1 Northern and Upper Western Regions

1) Lampang Group in the Lampang-Phrae area, northern Thailand

The Lampang Group in central north Thailand was formed in two adjacent sub-basins namely the Lampang in the west and Phrae in the east (Chaodumrong and Rao, 1992) (Figure. 2.3). They are similar in their sediments and stratigraphy but slightly different in age in which the age of the Lampang sub-basin and Phrae sub-basin has been younging eastward (Chaodumrong and Burrett, 1997). Piyasin (1971) proposed "Lampang Group" for marine Triassic sedimentary rocks. The Lampang Group is separated from the Khorat Group on the basis of age and lithology. The age of the Lampang Group ranges from Lower Triassic (Scytian) to Upper Triassic (Norian). The Lampang Group, previously divided into 5 formations, has been revised into 7 formations (Chaodumrong, 1992), namely, in ascending order, the Phra That, Pha Kan, Hong Hoi, Doi Long, Pha Daeng, Kang Pla, and Wang Chin Formations (Figure 2.4). The first five formations occur in the Lampang sub-basin whereas the last three formations are in the Phrae sub-basin. Only the Pha Daeng Formation is widespread over both sub-basins. Chaodumrong and Burrett (1997) found the Lampang sub-basin occurred earlier than Phrae sub-basin. The Lampang Basin consists of 5 rock formations (Phra That, Pha Kan, Hong Hoi, Doi Long and Pha Daeng Formations). Several bivalves and an ammonite including *Daonella*, *Posidonia*, *Costotaria*, *Claraia* and *Paratrachyceres* indicating Lower to Middle Triassic (Kraiskabian to middle Carnian) have been

recognized. The Phrae sub-basin contains 3 rock formations : Pha Daeng, Kang Pla and Wang Chin Formations (Figure 2.5). Fossils of *Halobia*, *Posidonia* and *Palaeocardita*

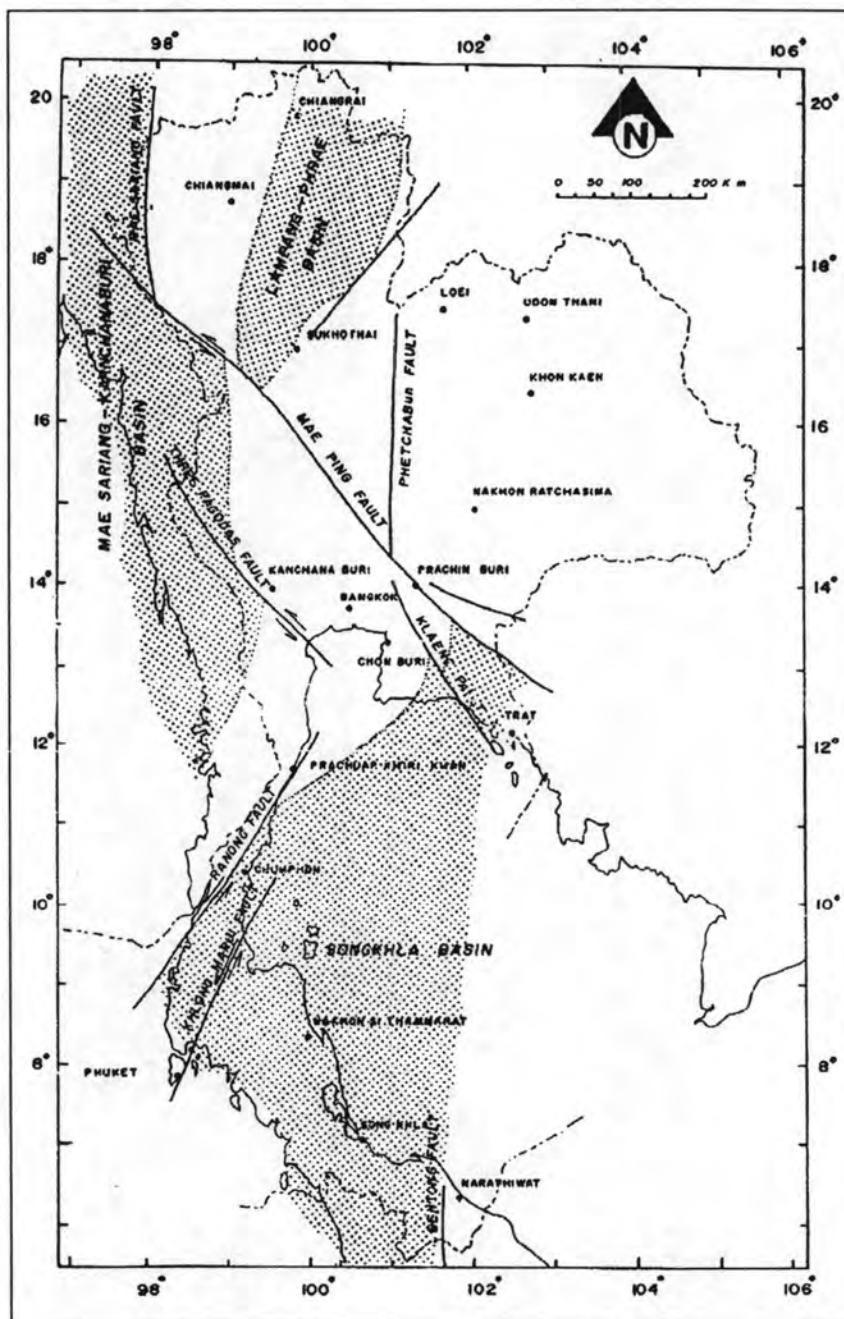


Figure 2.2 Map showing marine Triassic basins in Thailand (after Chonglakmani and Grant-Mackie, 1993).

indicate the age of Middle to Late Triassic (or middle Carnian to Norian). In most areas, the Lampang Group unconformably overlies inferred Permo-Triassic volcanics. The Lampang-Phrae Basin unconformably and conformably overlies the Permian strata. The conformable contacts occur particularly in the Lampang sub basin. It is both conformably and unconformably overlain by red beds of possibly Jurassic age. The maximum thickness is estimated at 3000 m and 2000 m in the Lampang and Phrae sub basins, respectively.

A) Phra That Formation: the name of this formation is from Phra That Muang Kham temple, and it is 12 km southeast of the town of Lampang. The sequences at the type locality, Phra That Muang Kham temple, are poorly exposed. An additional reference locality is proposed here at km 31.6 to 31.9 on the Lampang-Denchai highway. The thickness ranges from 90 to about 650 m. Lower part of the Phra That Formation is characterized mainly by alternating beds of feldspathic sandstone, conglomerate, siltstone and mudstone. These are mainly red, thin to thick and nonparallel beds with normal graded beds. Conglomerate clasts are mainly volcanics. The upper part of the formation generally consists mainly of gray mudstone and rare thin- to thick-bedded gray sandstone and limestone. Fossils, particularly bivalves, occur commonly in this upper part. The age ranges from early Scythian to early Anisian. The lower part of the formation contains *Eumorphotis multiformis* of Scythian age while mudstone in the middle part contains *Costatoria* assemblage of early Anisian age (Chaodumrong and Burrett, 1997). The relationships between the Phra That Formation and its underlying formations can be classified into three types: (1) unconformity on the top of Permian-Triassic volcanic rocks, (2) unconformity on the top of Permian limestones and older formations, and (3) a conformable contact with Permian-Triassic volcanic rocks or Permian sediments (Feng et al., 2005).

B) Pha Kan Formation: The name of the formation comes from Doi Pha Kan north of Ban Tha Si. This formation was proposed by Piyasin (1972). The type section is at the Phra That Muang Kham temple but Doi Chang and the Phra Thu Pha limestone quarry are regarded as the reference sections (hypostratotypes) of the Pha Kan Formation. The Pha Kan Formation consists of three limestone members and one

intervening clastic member: Wiang Sawan, Chang Garb, Cave Temple, and Muang Kham Members. In some areas, the formation is made up almost entirely of limestone; in the other it has an intervening clastic member (Table 2.1) (Chaodumrong and Burrett, 1997). The formation, 250 to 600 m thick, overlies the Phra That Formation conformably consisting mainly of thin-bedded to massive limestones and oolitic limestones, interbedded with shales, sandstones and mudstones, and contains an Anisian bivalve fauna represented by *Costatoria goldfussi mansuyi* (Chonglakmani and Grant-Mackie, 1993). Middle Triassic is proposed for the age of the Pha Kan Formation (Charusiri et al., 1994).

C) Hong Hoi Formation: Pitakpaivan (1955) proposed the name "Hong Hoi Shale and Sandstone" to represent sandstone and grayish green shale containing ammonoids and bivalves in the Mae Moh area. Later, Piyasin (1972) renamed it to Hong Hoi Formation. The type locality at a good exposure of the Hong Hoi Formation crops out from Huai Mae Dum to Huai Muang NE of Ban Tha Si. The Hong Hoi Formation is generally lying between the limestones of the overlying Doi Long Formation and the underlying Pha Kan Formation. However, in some places it may be conformably overlain by the Pha Daeng Formation, conformably underlain by the Phra That Formation or Permian strata. It consists mainly of fine-grained turbidites that can be subdivided into three members: the Tha Si, Mae Dum Sandstone and Huai Muang (Chaodumrong and Burrett, 1997). The formation with the thickness of 650–1000 m thick, overlies conformably the Pha Kan Formation. It is characterized by a succession of alternating gray to greenish gray mudstones, siltstones, sandstones and conglomerates, containing Ladinian-early Carnian bivalves and ammonoids, such as *Daonella indica* Bittner, *Halobia* cf. *subcomata* Kittl, *Protrachyceras* cf. *longobardicum* (Mojs), *P.* cf. *regoledanum* (Mojs), and *Trachyceras* cf. *aon* (Munster) (Chonglakmani and Grant-Mackie, 1993).

D) Doi Long Formation, named after the Doi Huai Long, is situated 40 km NE of the town of Lampang (Chonglakmani, 1981). The Doi Long Formation is characterized by massive bedded, light gray to gray packstone to grainstone of peloids, oncoids and algal debris with minor bioclasts, oolite and stromatolite beds or lenses.

Macrofossils are scarce but abundant locally, especially in the upper part of the formation. The formation has the thickness 230 m at the Doi Huai Long area (Chaodumrong and Burrett, 1997). The middle Carnian *Hollandites*–*Balatonites* fauna was found in this formation (Chonglakmani and Grant-Mackie, 1993). Charusiri et al. (1994) confirmed that the formation occurred locally, formed as lens-shaped strata, and changed laterally with the underlying the Hong Hoi Formation. In the upper part, the Doi Long Formation grades vertically into gray to reddish brown limestone conglomerate.

E) Pha Daeng Formation: The formation was named after Doi Pha Daeng by Piyasin (1972). Limestone conglomerates occurring within the red beds in the lower part of the sequences are considered as part of the Pha Daeng Formation which was contrast to the original proposal. This formation occurs in both Lampang and Phrae sub basins. The type section is located along Doi Pha Daeng through Huai Ting Tue. An additional reference locality is situated along km 50.5 to 61 and km 45+020 m to 45.4 on the Rong Kwang-Ngao highway. The formation has thickness ranging from 200 to 700 m and possibly, in places, up to 1000 m thick (Chaodumrong and Burrett, 1997). This formation consists mainly of red shales, sandstones, and conglomerates in the basal part, and grades up into gray shales, siltstones, and sandstones. Late Carnian *Halobia parallela* and *H. cf. yunnanensis*, and typical early Norian forms reported from Europe, such as *Halobia distincta* and *H. dilatata*, were found in gray siltstones of this formation (Chonglakmani and Grant-Mackie, 1993). Chonglakmani (1972) reported fossils of *Hettangia* in siltstone sorting upon basal conglomerates. Charusiri et al. (1994) considered that the Pha Daeng Formation took place in the non-marine environment but Chaodumrong and Burrett (1997) confirmed that the formation was deposited in the fan-deltas environment.

F) Kang Pla Formation: The type section is at km 45+500 m to 1045+625 m on the Rong Kwang-Ngao highway. The formation varies in thickness from 76 m at the type locality at km 45.5 on the Rong Kwang-Ngao highway to 38 m at the section in the south at km 69 on the Lampang-Denchai highway. These two locations are possibly only the feather edges of a large lensoidal limestone body. The Kang Pla Formation consists mainly of thin to massive bedded, light to dark gray limestone with minor interbedded

clastics. The lithology varies laterally; in some areas oolite or skeletal grainstone is developed, in the others limemudstone and peloidal packstone are dominant. The formation ranges in age from middle Carnian to lower Norian. Middle Carnian *Halobia comata* and *Spiriferina* were reported from gray limestone in Ban Pha Kho, 15 km north of Tam Bon Ban Pin. The lower Norian conodont, *Epigondolella abneptis*, is found in limestone at km 69 on the Lampang-Denchai highway (Chaodumrong and Burrett, 1997). The formation is interpreted to have been deposited in the shallow environment (Chaodumrong and Rao, 1992).

G) Wang Chin Formation: The formation was proposed for the Huai Chan Member at Huai Chan of Song District, and for the Mae Lu Sandstone and Phu Tap Members at km 54+730 m to 55+930m and 66+350 to 66+770 m along the Lamphang-Denchai highway. The formation is subdivided into three members as the Huai Chan, Mae Lu Sandstone, and Phu Tap (Table 2.1). *Halobia* is a typical fossil that often found in the Mae Lu Sandstone and Phu Tap Members (Chaodumrong and Burrett, 1997). The thickness of this formation is ranging from 600 to 1600 m thick. It is composed of gray to greenish gray shales and sandstones with interbeds of mudstones, siltstones and conglomerates. It contains late Carnian to early Norian bivalves (Feng et al., 2005). The Wang Chin Formation is confirmed to have occurred in the deeper and outer shelf environment (Chaodumrong and Rao, 1992).

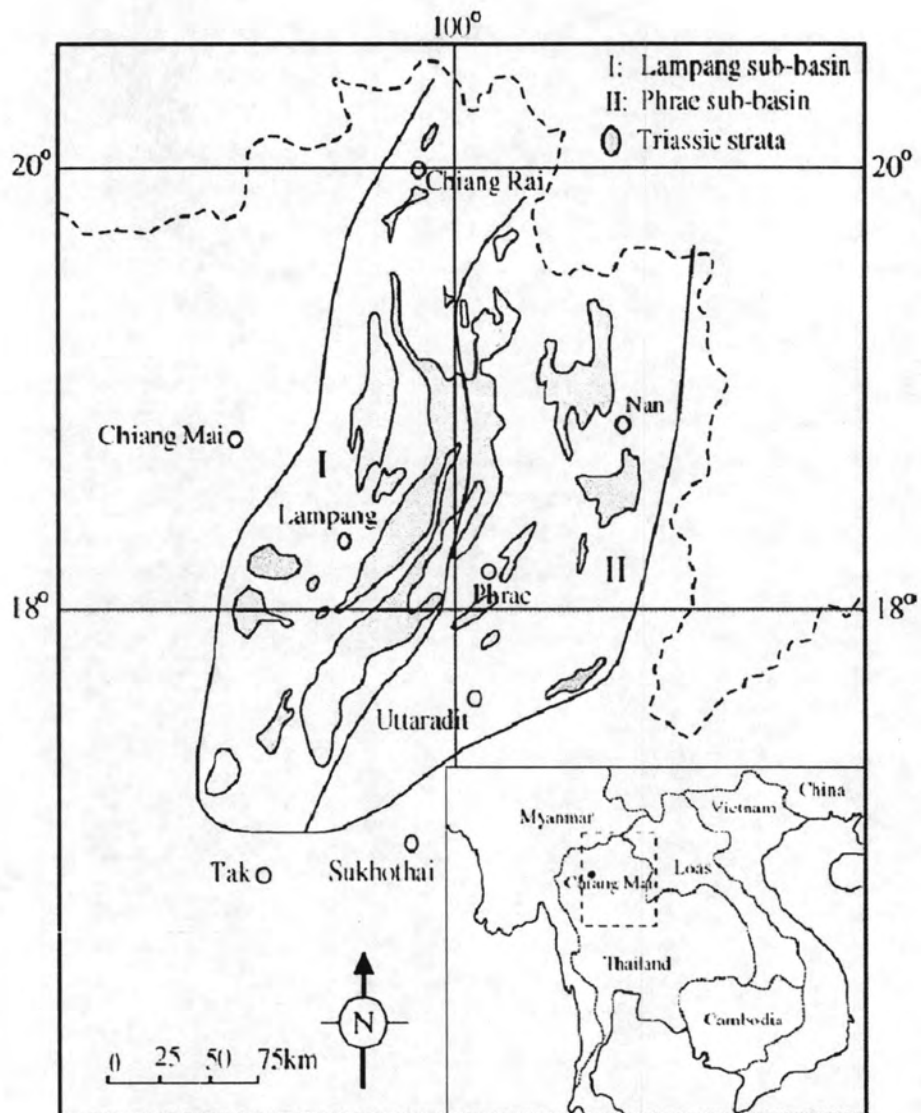


Figure 2.3 Location of Lamphang-Phrae Basin and the distribution of the Triassic in the Basin (after Feng et al., 2005).

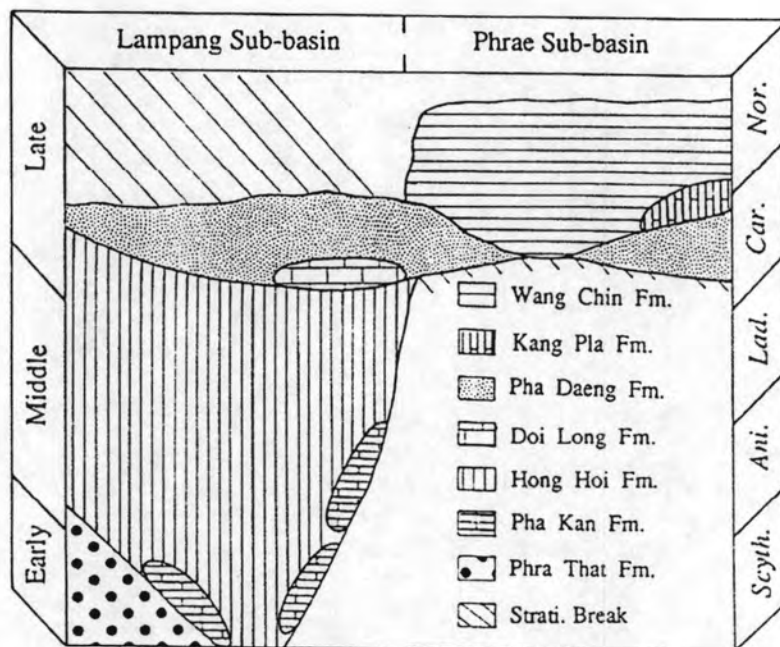


Figure 2.4 Simplified stratigraphic relationships within the Lampang Group (after Chaodumrong, 1992).

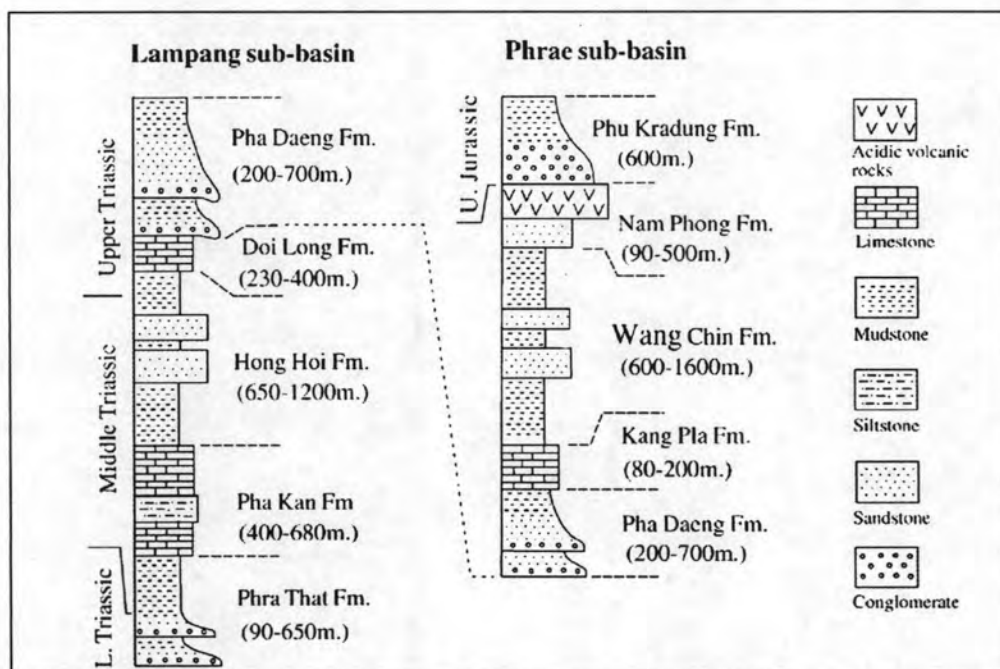


Figure 2.5 Triassic stratigraphic sections of Lampang-Phrae Basin, North Thailand (after Feng et al., 2005).

Table 2.1 Stratigraphic columnar sections of the Lampang Group in Lampang and Phrae basins (after Chaodumrong and Burrett, 1997).

T R I A S S I C	B A S I N	Lampang Basin			Phrae Basin		
		Sop Prap- Ngao-	Chae Hom- Pha Yao-	Lampang Chiang Ra	Phayao-Ngao Long-Wang Chin		
Upper	L A M P A N G				Wang Chin Fm	Huai Chan	Thu Tap Mae Lu SS Phu Tap
					Kang Pa Fm		
					Pha	Daeng	Fm
Middle	A N G	Doi Long Fm					
		Hong Hoi Fm	Mae Dum SS	Huai Muang Tha Si			
Lower		Pha Kan Fm	Muang Khan Chang Grab	Cave Temple			
		Wiang Sawan					
		Phra That Fm					

2) Nam Pat Group in the Nan-Uttharadit area, northern Thailand

Marine Triassic rocks exposed in the vicinities of Na Noi, Tha Wang Pha, and Song Khwae Districts, and Nam Pat District of Nan, and Uttaradit Provinces, respectively can be classified into 2 formations, in ascending order: Hin Lat and Huai Bo Khong formations on the basis of their lateral facies changes (Meesook et al., 2002). The Nam Pat Group, approximately 1400 m thick, consists of greenish gray to red conglomerates with clasts mainly of volcanic rocks with subordinate sandstones, granites, limestones, cherts and white quartz, and sandstones interbedded with dark gray to greenish gray mudstones displaying graded beds of Bouma's sequence. Based on the conodont *Pachycladina* sp. indet, the Scythian age is given for the Nam Pat group. According to

the limestone unit (trl) (not include in the Nam Pat group), the rocks consist of dark gray, thin- to thick-bedded limestones interbedded partly with mudstones and sandstones. The limestone unit (trl), interpreted as the lateral facies changes with the Huai Bo Khong formation is well exposed as isolated hills north of Na Noi District and west of Bo Klua District of Nan Province. Based on the ammonite *Unionites* and the bivalve *Costatoria goldfussimansuyi*, the Middle Triassic age is given for the limestone unit (Meesook et al., 2002).

3) Mae Sariang Group in the Mae sariang area, northwestern Thailand

Bunopas (1981) first proposed the name Mae Sariang Group (Figures 2.6) and stated that the type section of the Mae Sariang Group is at the western part of the road between km 5 to km 10 from Mae Hong Son Province to Mae Sariang District. In his brief description, the Mae Sariang Group consists of 50 m-thick conglomerate in the lower part, 700 m-thick interbedded gray shale/siltstone and sandstone, and 100 m-thick sandy shale. Marine Triassic rocks in the vicinity of Mae Sariang District, Mae Hong Son Province, are unconformably underlain and overlain by Paleozoic and Jurassic rocks, respectively. The rocks can be divided into 2 informal formations as upper and lower formations with total thickness of 220 meters, consisting of (from bottom to top) greenish red, thin-bedded (< 10 cm) cherts intercalated with thin-bedded claystones and partly with limestones. Besides, reddish brown to gray conglomerates, sandstones and mudstones are also present. The sedimentary characteristics show the Bouma sequence with graded beds, and fining upward sequence. Clasts of conglomerate and sandstone consist of chert, metamorphic rock, and granite. Based on the radiolarians (Caridrot et al., 1993; Tofke et al., 1993) and bivalves *Halobia comata*, *Posidonia*, *Halobia styriaca* Mojs, *Daonella cf. sumatrensis* Volz found in this sequence, they indicate Middle Triassic age.

Tofke et al. (1993) made a detailed study on 3 sequences of Triassic sedimentary rocks along the road from Mae Sariang to Mae La Noi Districts. They reported that these marine Triassic rocks consist mainly of red, green, gray ribbon chert beds in the lower sequence with radiolarian fossils and intercalation of claystone and

siltstone. Each chert bed is about 10 cm-thick. The middle sequence is composed largely of pelagic limestone ranging in color from reddish to greenish and light to dark gray with individual beds do not exceed 10 cm, and the overall thickness is about 20 m. Radiolarian and shell fragments are found only in the light gray limestone bed along the road at km 119.625, Highway 108. The upper sequence is regarded as turbidite sequence mainly containing graded to crossed-bedded siliciclastic strata of sandstone intercalated with shale. The thickness is varied from 5 to 20 cm and some strata are up to 100 cm. The total thickness of these 3 sequences is more than 100 m. Well-preserved bivalves found in shale indicate the age of Middle to Late Triassic (Ladinian to Carnian).

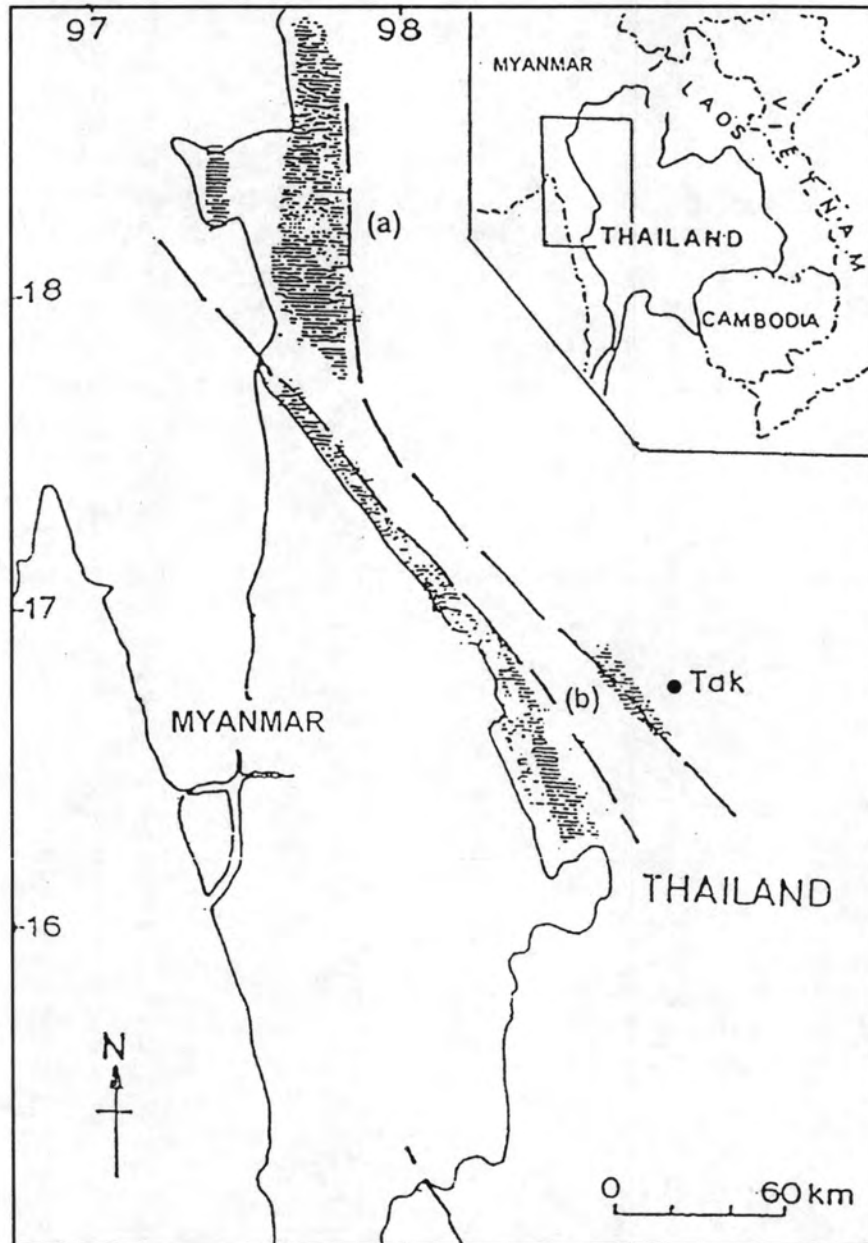


Figure 2.6 Map showing distribution of marine Triassic sediments of the Mae Sariang Group (a) and the Mae Moei Group (b) (after Bunopas, 1981).

4) Mae Moei Group in Mae Sot area, western Thailand

This sedimentary rock unit was proposed by von Braun and Jordan (1976) for Mesozoic sedimentary sequence. It is exposed in the Mae Moei and Mae Sot areas of western Thailand (Figures 2.7). The Mae Moei Group consists of two major units-the Lower and Upper Units. Two sections were stratigraphically studied in detail by von Braun and Jordan (1976), one along Kamawkala gorge of the Mae Moei River (Kamawkala section) and the other along Huai Hin Fon stream at the Tak-Mae Sot highway (Mae Sot section).

In the Huai Hin Fon area (Mae Sot section), the observed oldest rock sequence overlies unconformably the Permian sediments at km 67.5 road from Tak to Mae Sot. These sequences are called the Pang Manora Sandstone (390 m-thick) consisting mainly of yellow to red sandstone and shale in the upper part, gray to red sandstone in the middle, and poorly sorted limestone conglomerate in the lower. The younger unit is the Mae Pa Luang shale (470 m-thick) consisting of red to gray shale with *Myoshoria* sp. and *Gonodon* aff. *mellingii* and thinly bedded sandstone and limestone intercalation. The almost top sequence is the Huai Hin Fon Limestone (680 m-thick) consisting of clayey to silty limestone, and the topmost sequence is the Huai Hin Fon shale (770 m-thick) composed mainly of greenish gray siltstone, shale, and sandstone with *Posidonia* in the upper part and dark gray shale with ammonoids in the lower part.

In the Mae Moei area (Kamawkala section), 2 sections were recognized. The lower sequence is about 900 m thick. It contains greenish gray shale with interbedded sandstone in the lower part. This sequence is almost similar to that of the Pang Manola Sandstone and the Mae Pa Luang shale of the Huai Hin Fon section. *Halobia* and *Posidonia* bivalves and ammonidia fossils in shale suggest the age of Late Triassic. The middle sequence is characterized by the Kamawkala Limestone. The age was subsequently proved as Jurassic which is similar to the Huai Hin Fon Limestone. The upper sequence is dominated in the lower part by 235 m thick. It is composed of red conglomerate with poorly sorted of chert, volcanic, limestone, sandstone and quartz rock fragments and intercalated with sandstone and limestone beds. In the upper part

(140 m thick) the sequence is intercalation of gray mudstone and sandstone with abundant fossils of *Daonella samatrenis* volz, suggesting the age of Middle Triassic.

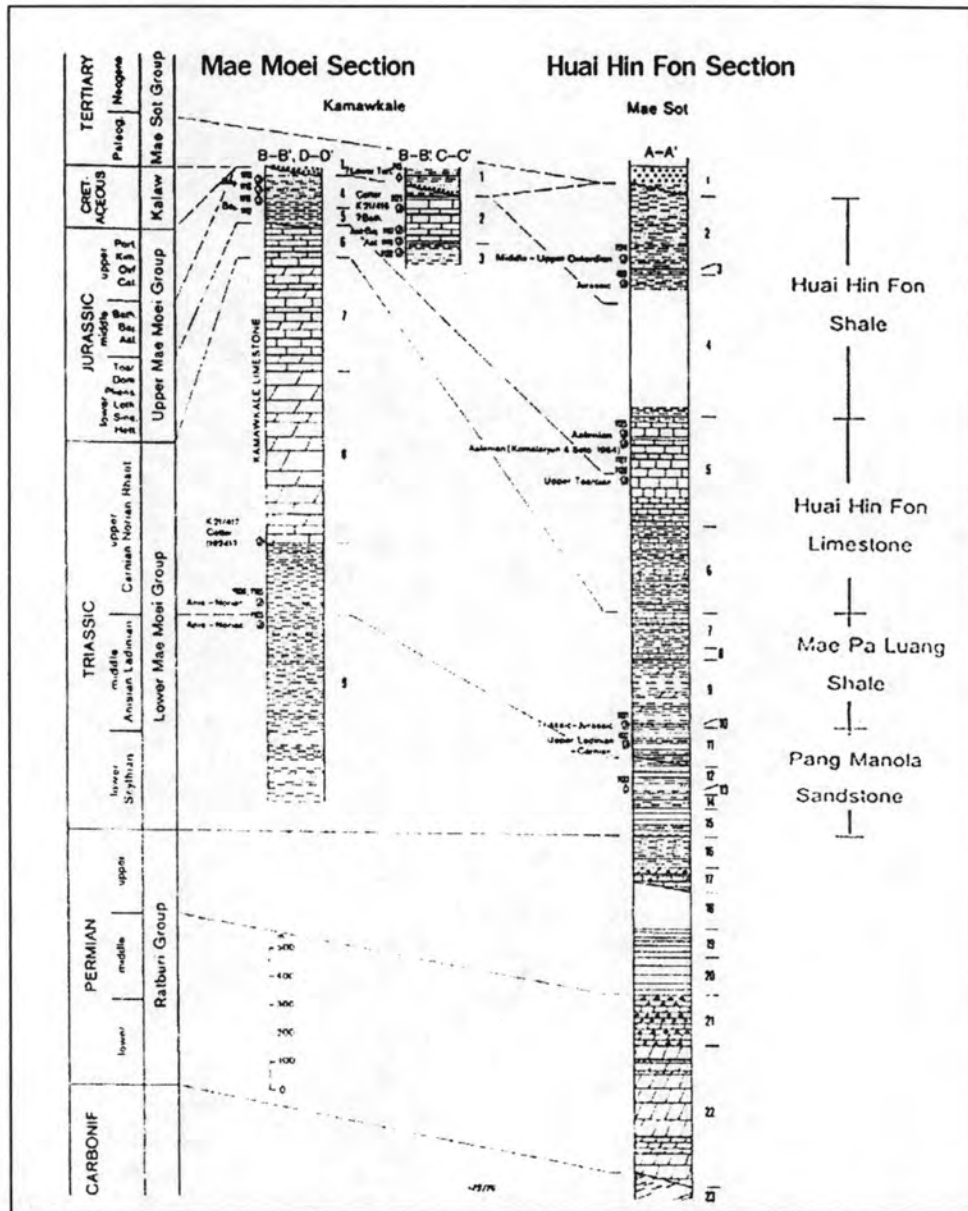


Figure 2.7 Composite stratigraphic columns in the Kamawkala and Mae Sot areas (after Von Braun and Jordan, 1976)

The Kamawkala limestones have been confirmed as the Jurassic age. These limestones are related to the Triassic rocks with fault contacts. The Triassic rocks exposed in the vicinity of Tak Province as a narrow strip trending NW-SE along the Mae Ping Fault Zone, are 3 km wide and 20 km long. The rocks here are 350-500 m thick (Meesook et al., 2002).

5) Tak Group in the Tak area, western Thailand

This sedimentary stratigraphic unit was proposed by Bunopas (1976) for a Triassic sequence of 400 m thick sedimentary strata exposed as narrow and long outcrops in the western part of the east-dipping Lansang thrust fault. It is about 12 km west of Tak city. The Tak Group comprises mainly red beds of conglomerates interbedded with sandstone and gray beds of sandstone, limestone and shale. The bivalve *Daonella sumatnensis* suggests the age of Ladinian (Middle Triassic) (Bunopas, 1981).

6) Marine Triassic rocks of Kanchanaburi, western Thailand

Kemper et al. (1976) proposed the Si Sawat Limestone for a stratigraphic unit consisting largely of Triassic to Jurassic limestones exposed in areas of Si Sawat District, northwest of Kanchanaburi Province (Table 2.2). The type section of the Si Sawat Limestone is at Huai Chongkrong stream, parallel with the road from Si Sawat to Noen Sawan, about 6 km west of Si Sawat town. Marine Triassic rocks crop out in the vicinities of Si Sawat and Thong Pha Phum Districts of Kanchanaburi Province (Kemper, 1976; Bunopas, 1981), consisting of the 200 m thick sequence of limestones, siltstones, mudstones and sandstones. Whereas mudstones display the distinctive pencil structures; limestones are replaced by dolomites. At Si Sawat District, the bivalves *Halobia* and *Posidonia* were found and early Anisian conodonts *Neogondolella mombergensis* (Tatge), *Neospathodus aegaeus* (Bender), *Gondolella* cf. *constricta* (Mosher & Clark), were discovered in limestones together with the Norian conodont *Epigondolella abneptis* (Huckriede). Previously known Triassic conglomerates and

sandstones at Kaeng Raboet have been reassigned as Jurassic in age because of the presence of Jurassic fossils in limestone clasts (Meesook et al., 2002).

		Thong Pha Phum Area	Si Sawat Area		Fossils	
CRETACEOUS			no proof			
JURASSIC	Malm	U	no proof	?	light brown grey and light grey limestone; red conglomerate	foraminifera (<i>Kurnubia</i>), algae, gastropods, brachiopods
		M				
	Dogger	L	? ?			
		U				
		M			light brown grey limestone	foraminifera (<i>Lucasella</i> , <i>Haurania</i> etc.) algae
		L				
Lias	U	~ 300 m				
	M			middle to dark grey limestone	foraminifera (<i>Orbitopsella</i>)	
TRIASSIC	Rhaetian			partly red sandstone, shale, marl and limestone	no fossils	
				light to dark grey limestone	conodonts foraminifera (<i>Involutina</i>), calc. algae (<i>Doucina</i>), brachiopods, corals	
	Norian					
	Carnian	± 200 m				
	Ladinian					
	Anisian				light to dark grey limestone	conodonts
	Scythian					
PERMIAN				grey limestone	partly rich in fossils	

Table 2.2 Stratigraphic column of Triassic and Jurassic rocks of Si Sawat District, northwest of Kanchanaburi Province (after Kemper, Maronde, and Stoppel, 1976).



2.2.2 The Eastern Regions

1) Marine Triassic rocks of eastern Thailand

Marine Triassic rocks in eastern Thailand can be divided into 4 formations, namely, in ascending order: the Sookpriwun, Noen Po, Pong Nam Ron and Noen Phu Yai Yua Formations (Meesook et al., 2002).

A) Sookpriwun Formation, 100 m plus thick, consists of gray, dark gray and violet brown limestones having slightly deformation. The formation is unconformably underlain by Late Permian rocks containing the foraminifera *Meandrospra pusilla* Ho, *Glomospira tenurfistula* Ho, and algae *Aeolissacus tintinniforis* Misik indicative of Scythian-Ladinian age.

B) Noen Po Formation is composed of gray to dark gray mudstones and shales intercalated with 3-5 cm thick gray cherts yielding the Middle to Late Triassic radiolaria *Triassocampe*, *Syringocapsa*, *Archaeospong oprunum*. The age of Noen Po Formation is younger than ones of the Sookpaiwun Formation. Its type section is at Khao Noen Po, west of Chantaburi Province. This formation is mainly mudstone interbedded with volcanoclastic sandstone and about 250 m thick.

C) Pong Nam Ron Formation is well exposed at Klong Pong Nam Ron, Pong Nam Ron District, Chantaburi Province. The rocks observed in the northwest-southeast trend expose from Wang Nam Yen District, Sra Khaeo Province southward to east of Trat Province. The formation is composed largely of thin- to thick-bedded, partly overturned and cleaved graywacke and mudstone with conglomerate intercalation (Figures 2.8). The occurrence of abundant volcanic clasts and fusulinid-bearing limestone and the alternating bed of turbiditic sandstone and shale of Bouma sequence, led to suggest that the Pong Nam Ron Formation took place as submarine fan environment depositing in an active margin nearby continents (Srinak, 2002). The Pong Nam Ron Formation, 200 m thick, consists of dark gray, poor-sorted, thick-bedded, feldspathic sandstones. The sandstone composition is mainly of volcanic and feldspar, and subordinate quartz. In some places, sandstones are intercalated with mudstones and conglomerates having clasts of well-rounded, poor to moderate sorted volcanic

rocks, and fusulinid-bearing limestones. The conglomerates also display fining upward sequence grading up to the Noen Phu Yai Yua Formation.

D) Noen Phu Yai Yua Formation, 300 m thick, is conformably underlain by the Pong Nam Ron Formation. It contains dark gray, medium-grained, well-bedded (10-20 cm) sandstones interbedded with parallel-bedded mudstones displaying prominent Bouma sequence and graded beds particularly in sandstone beds grading up to mudstones with sharp and planar contacts and sandstone : shale ratio of 2: 1 to 1 : 1. This formation is interpreted as having been deposited in the submarine fan environment.

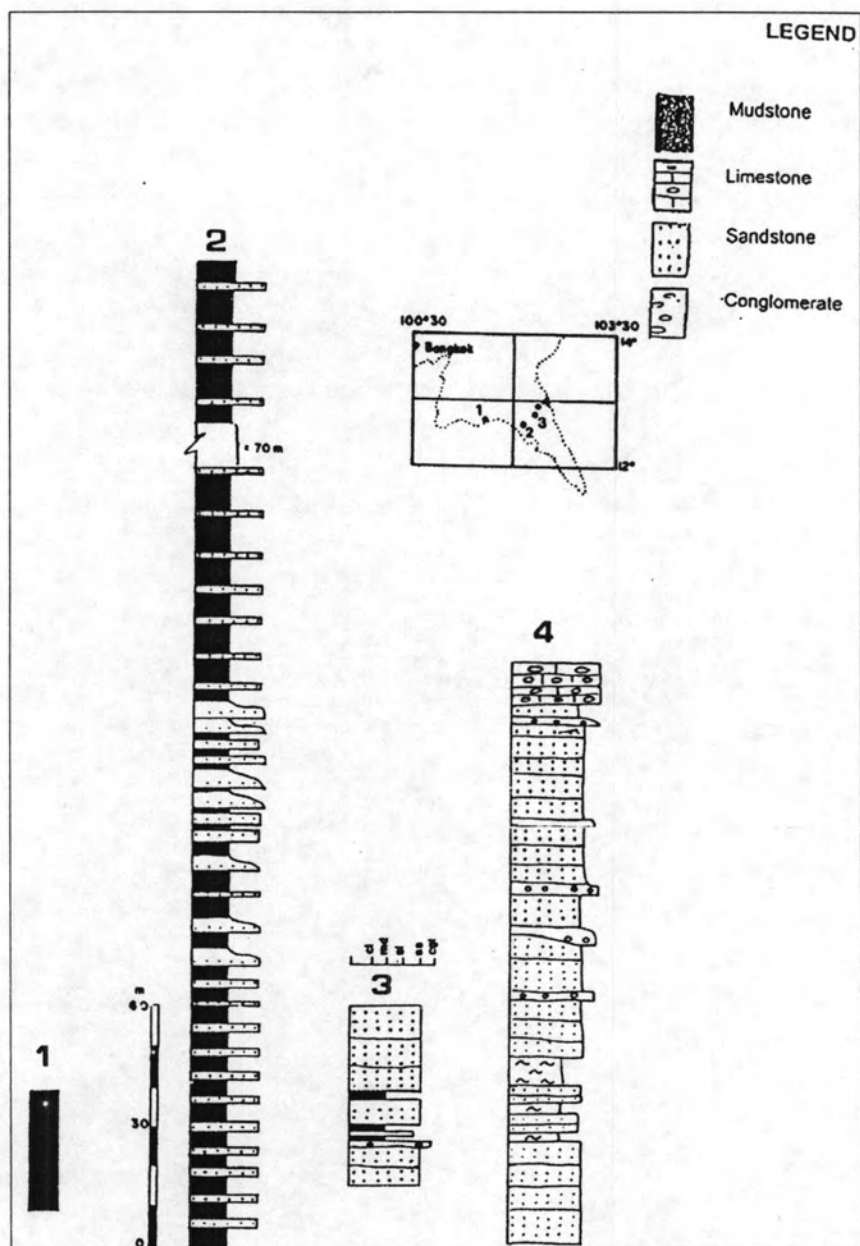


Figure 2.8 Stratigraphic sequence of the Pong Nam Ron Formation in eastern Thailand (after Srinak, 2002). 1. Ban Tha Rua, 2. Noen Punyai Yua, 3. Khao Klua, and 4. Klong Nam Ron.

2.2.3 Southern Regions

1) Marine Triassic rocks of southern Thailand

Marine Triassic sedimentary sequences in southern Thailand are widely exposed in 2 main areas of Songkhla and the Phattalung Provinces.

In Saba Yoi District of Songkhla Province, Grant-Mackie et al. (1980) have divided the rocks into 4 units, namely, in ascending order: the Suan Cham Formation, Chedi Conglomerate, Khlong Kon Limestone and Sani Formations. The Suan Cham Formation consists of the 1,700 m thick siltstones and well-bedded sandstones. The Chedi Conglomerate comprises thick-bedded conglomerates and sandstones with lenses of medium-grained sandstones. The Khlong Kon Limestone is composed mostly of 600 m thick, gray, thick-bedded limestones. Sashida et al. (1999) mentioned that the Khlong Kon Limestone is interpreted to be deposited in the low energy, back-reef or lagoon environments and this formation ranges in age from Middle to Upper Triassic on the basis of the foraminifera. The Sani Formation consists of siltstones, fine-grained sandstones, dark gray cherts and fine- to medium-grained conglomerates with total 4,300 m thick (Meesook et al., 2002).

In the Na Thawi area, Songkhla Province, the marine Triassic rocks contain the bivalve *Daonella sumatrensis* Volz collected from Khlong Mak along Highway No. 42 indicating Carnian age (Late Triassic). Grant-Mackie et al. (1980) have established new lithostratigraphic units, namely, in ascending order: the Mi Kiat Conglomerate, Na Thawi Formation, Wang Yai Siltstone and Lam Long Sandstone. The Mi Kiat Conglomerate is approximately 500 m thick, consisting of conglomerates and sandstones. The Na Thawi Formation is composed of siltstones and siliceous sandstones with 3,000 m thick sequence. The bivalve *Daonella multilineata* (Jones) collected from siltstones indicates the Middle Carnian age (lower Late Triassic). Sashida et al. (1998) reported the presence of the Carboniferous radiolarian in chert lenses at Ban Wang Yai along Highway No. 42. The gray, thin-bedded, calcareous siltstones of the Wang Yai Siltstone and fine-grained, thin-bedded sandstones of the Lam Long Formation are 225 and 3,700 m thick, respectively (Meesook et al., 2002).

In the Phatthalung area, marine Triassic rocks have been established by Ampornmaha (1995) as the Chaiburi Formation, consisting of 3 members in ascending order (Figures 2.9): the Phukhaothong Dolomite, Chiak Limestone and Phanomwang Limestone Member, respectively. The formation consists of pale gray to violet gray, well-bedded, thin- to thick-bedded limestones, dolomitic limestones and dolomites with 500 m thick. The rocks are trending N-S and dipping 40° E; its lower part consists of dolomites in which Mazin et al. (1991) described the new ichthyopterygian (Reptilia) indicating Early Triassic age; the middle part comprises limestones intercalated with nodular and thin-bedded cherts; the upper part is composed of thick to massive limestones on the basis of the microfacies analysis. Age determination of the rocks is based mainly on the conodont indicating Lower to Upper Triassic. The stratigraphic correlation of the Chaiburi Formation with the Triassic rocks in other regions including the northwestern peninsular Malaysia is summarised in Table 2.3 (Meesook et al., 2002).

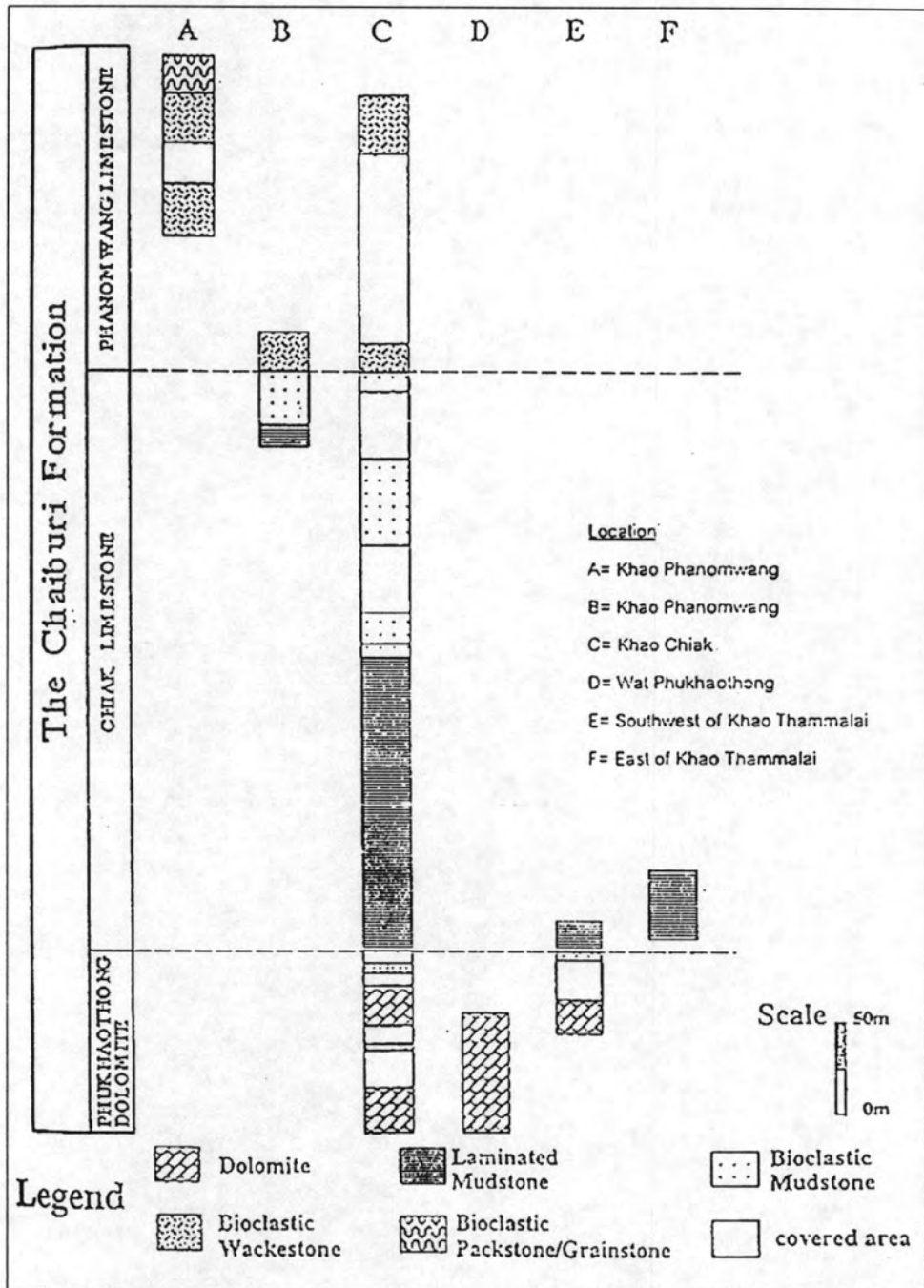


Figure 2.9 The Chaiburi Formation consists of 5 microfacies in each section (after Ampornmaha, 1995).

Table 2.3 The stratigraphic correlation of the Chaiburi Formation with the Triassic rocks in other regions including the northwestern peninsular Malaysia (after Ampornmaha, 1995).

		NORTHERN	NORTHWESTERN			WESTERN	SOUTH-EASTERN	SOUTHERN			Northwest Peninsular Malaysia	
			MAE SARIANG	MAE SOT	TAK			SI SAWAT	SONGKHLA	PHANGNGA		PHATTHALUNG
TRIASSIC	LATE	Wang Chin	?	Kamawkala Limestone	?	Foram-bearing sh	?	silts with <i>Daonella</i>	silts & ls with <i>Daonella</i> , <i>Posidonia</i>	Phatthalung Gr.	Kodiang/Chuping Limestone	Semanggal Formation
	MIDDLE	Kang Pla Pha Daeng Dol Long	sh with <i>Halobia</i> , <i>Daonella</i> , <i>Posidonia</i>	sh & ss with <i>Halobia</i> ?, <i>Posidonia</i>	ls with <i>Daonella</i>	ls with <i>Halobia</i> Conodont-bearing ls	?	Na'Thawi Fm. Khlung Kon Limestone		Phanomwang Limestone Chiak Limestone		
		Hong Hol					Foram-bearing ls	Mi Kiat cong.	Phukhaothong Dolomite			
		Pha Kan				Thong Pha Phum cong.						
	EARLY	Phra That	?	Redbed	Redbed							

Note : sh = shale, ss = sandstone, ls = limestone, cl = conglomerate