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DETAILED STRATIGRAPHY OF THE BAN THASI AREA, LAMPANG, NORTHERN THAILAND: IMPLICATIONS FOR PALEOENVIRONMENTS AND TECTONIC HISTORY

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Abstract

Ban Thasi area (370 km²) in Mae Moh District, Lampang Province is mostly underlain by marine sedimentary strata with minor nonmarine and volcanic rocks, including the Permian Ratburi Group, the Triassic Lampang Group, and the Permo-Triassic volcanics. The Permian Ratburi Group (400 m thick) consist principally of underlying Pha Huat formation (250 m, massive to bedded limestones), and Huai Tak formation (150 m, clastics with brachiopods and *Leptodus*). All of the sequences are located in the eastern part of the area. The Triassic Lampang Group (3,700 m thick) is composed largely of a wide variety of rocks, including red beds, limestones, and marine turbidites. The Lampang Group can be further subdivided into 5 formations, from older to younger, as Phra That Formation (830 m, grey and red clastics, with bivalves, ammonoids, brachio-pods), Pha Kan or Doi Chang Formation (500m, limestones, with bivalves and brachiopods), Hong Hoi Formation (1,350 m, clastic turbidites, with bivalves and gastropods), Doi Long Formation (200 m, grey limestones, with brachiopods and gastropods), and Pha Daeng Formation (850 m, nonfossiliferous red clastics). The Permo-Triassic volcanic rocks assigned herein as the Mae Man group comprises rhyolite and andesite with interlayered tuffs and agglomerates. This rock sequence only exposes in northwestern part of the study area. Structurally, the area is characterised by a large syncline in the central part with two small anticlines in northwestern and eastern parts. The NE-trending main fault in the central part conforms with the major Mae Tha and Uttaradit Faults.

All rocks were inferred to have been deposited in the tectonic Lampang Basin of the Chiang Rai-Lampang block, located at the easternmost margin of the Shan-Thai craton. The Permian Ratburi rocks may have occurred in the open marine shelf of the passive continental margin. Later, volcanic activity may have taken place during Permo-Triassic and produced felsic calc-alkaline volcanics and volcanic clastics, possibly indicating the east-dipping subduction zone beneath the Shan-Thai block. As a result of extension tectonics, the deposition of the Phra That clastics and epiclastics occurred in the back-arc basin at a shallow marine condition, in part with subaqueous non-marine environment. Subsequently, deposition of the Pha Kan non-clastics may have taken place in a shallow marine, ramp platform of a rift basin. Then the basin may have become closer and subsided as the Shan-Thai and Indochina microcontinents become closer and the deposition of the thick sequences of the Hong Hoi turbidites developed in the rapidly subsiding basin. Non-clastic Doi Chang sediments were deposited later and partly intertounged with the Hong Hoi clastics as small strata in the shallow-marine ramp platform basin. During the Late Triassic-Jurassic Shan-Thai may have collided with Indochina and the basin may have been closed , faulted, warped and uplifted. As a result, the Pha Daeng terrigenous clastic red beds, equivalent to the (older) Khorat Group, may have taken place as non-marine, molasse-type sediments, either belonging to the uppermost part of the Lampang Group or the Lower Khorat Mesozoic Group.

INTROCUCTION

Ban Thasi area (370 sq km, in map sheet 4945 I) is located in Mae Moh District, Lampang Province (Figure 1). The area is characterised by alternating, small intermontane basins within the NE-trending mountain range. Systematic geological studies were previously reported by Piyasin (1972), Liangsakul (1979) and Chonglakmani (1981), and recently by Chaodumrong (1992), Chonglakmani and Grant-Mackie (1993), Supananthi (1993), Charusiri and Galong (1994), and Galong and Charusiri (1994). The aim of this study is to present a new stratigraphy of the study area and to discuss it in terms of paleoenvironments related to tectonism.

GEOLOGY AND STRATIGRAPHY

The Ban Thasi area comprises principally two distinctively geological units; i. e. marine sedimentary strata and minor volcanic units (Figure 1). The marine strata are classified as the Permian Ratburi Group and the Triassic Group.

The Ratburi Group (up to 400 m thick) consists principally of two rock units including Pha Huat (older) and Huai Tak (younger) formations (Figure 2). The Pha Huat formation (300 m) consists mainly of high-angle dipping and deformed, massive to well-bedded, partly recrystallised, biomicritic to pseudosparitic limestones. The limestones usually form karst towers (Figure 3A). The unit also contains abundant fossils, namely brachiopods, corals and bryozoans, as well as chert nodules of various sizes. It usually forms small, narrow rugged topography and is widely distributed in the eastern part of the study area (Figure 3B).

Conformably overlying the Pha Huat unit is the east-dipping Huai Tak formation (150 m thick) which is composed largely of brown shale and dark grey slaty shale without ellipsoidal fractures. Pelecypods, brachiopods, bryozoans, and fusulinids were reported by Piyasin (1972). Due to its lithological indurability (Figure 3C), the unit is exposed only in a small, undulating terrane, particularly to the east. Unconformably overlying the Permian unit is Permo-Triassic Mae Man group (Supananthi, 1993). The group is characterised by volcanic and volcaniclastic facies, the latter (Figure 3D) being more common in the area. Rhyolite and andesite lavas locally with prominent flow structures and up to 10 m thickness, are quite distinct in the upper succession. Rhyolitic to andesitic tuffs, lapilli tuffs, and andesitic agglomerates of up to 20 m thickness are much more common in the lower part. The unit crops out only

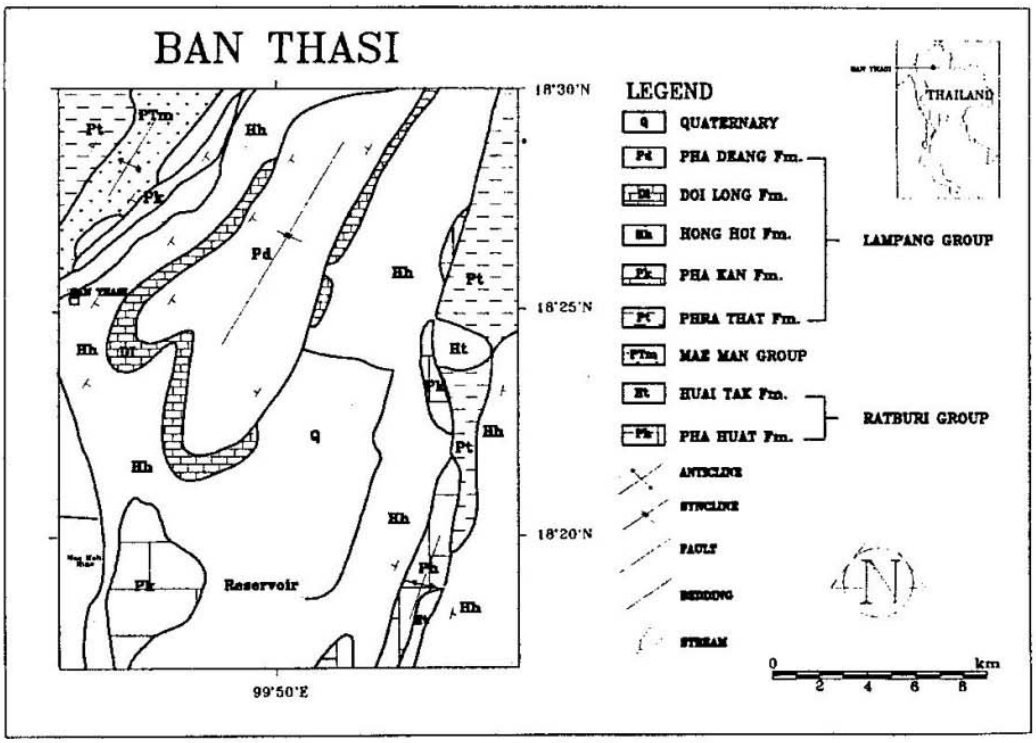

Figure 1. Simplified geological map of the Ban Thasi area, Lampang, northern Thailand (using AUTOCAD and GEOSOFT programmes by Galong and Charusiri, 1994).

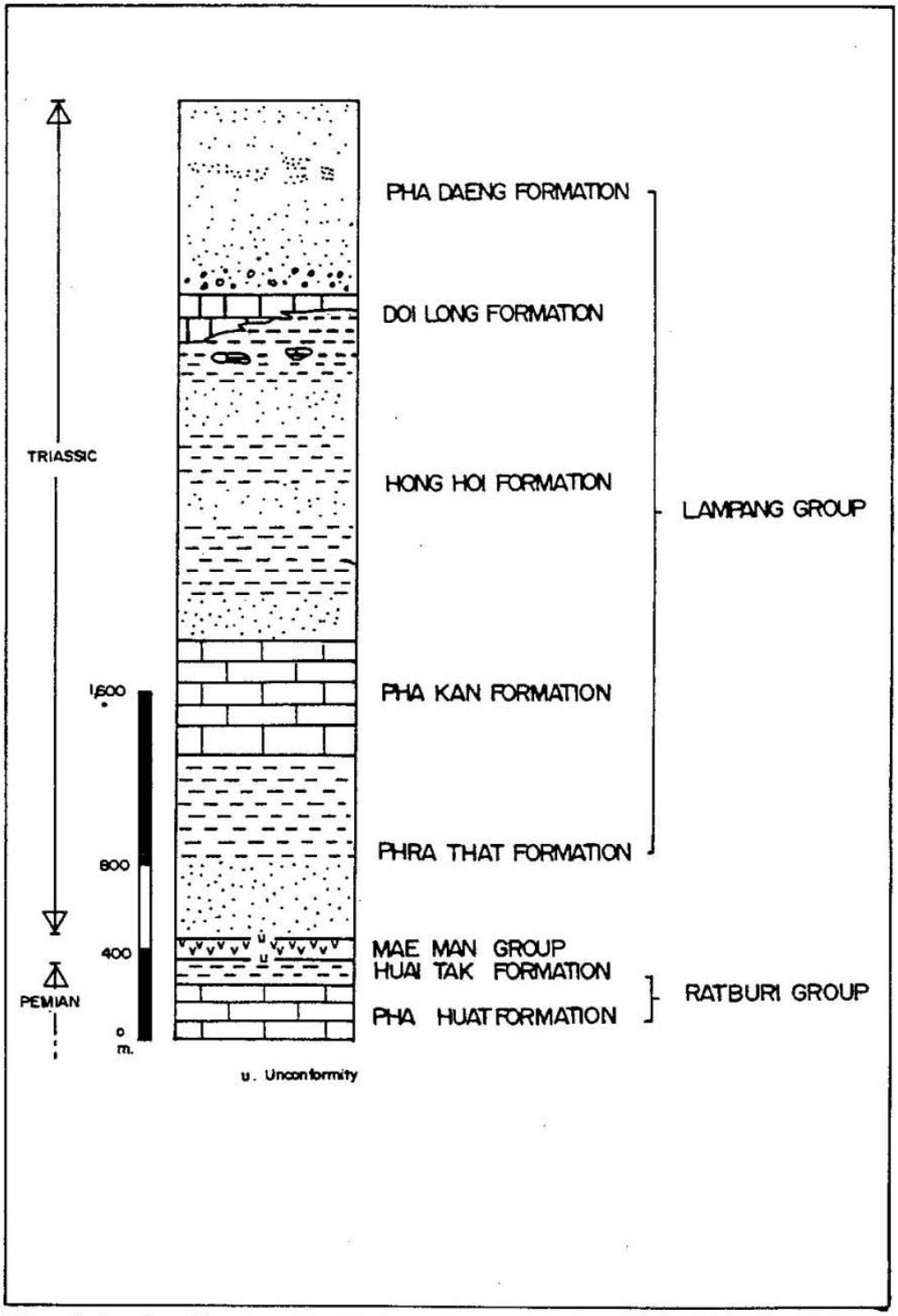

Figure 2. Stratigraphic column, Ban Thasi area, Lampang, northern Thailand (Supananthi, 1993).

in the northwest.

The Triassic unit (up to 3,700 m thick), which in parts lies unconformably over Permo-Triassic volcanic facies and/or Permian sediments is the most widespread unit in the study area. The Group can be stratigraphically divided into 5 formations, namely Phra That, Pha Kan, Hong Hoi, Doi Long and Pha Daeng Formations.

The Phra That Formation, the oldest unit of at least 830 m thickness, is exposed in the northwest and the east. Two members are recognised to belong to this formation. The older, Ban Chang King member (300 m thick) contains red to brown tuffaceous siltstone and protoquartzite to

Table 1. Summary of the Geology of the Ban Tha Si Area.

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AGE	FORMATION	LITHOLOGY	FOSSILS	ENVIRONMENTS	TECTONISM	BASIN
M Permian	Pha Huat	micrite	Fusulinids,brac.,corals	Shallow water, open marine shelf,clear water	Passive continental margin	onset stage
L Permian	Huai Tak	grey shale	Leptodus fusulinid, brachiopods			
Permo-Triassic	Mae Man	Volcanic volcaniclastic	No	Muddy water	Subduction - related volcanic arc	Initial stage
E Triassic	Phra That	Epiclastic, sand-siltstone grey to red	Bivalves(Costatoria, Unionites,Pteria Pecten),brac.,gas.	Shallow water, elongate basin near shore,neritic	Low-angle,high rate of subduction incipient rift basin	Middle stage
E M Triassic	Pha Khan	Micrite, sparite	Bivalves(Hoernesia, Elegantinia),corals Gastropods,brachiopods	Shallow marine near shore trop. ramp platform	Extension tectonics	
M Triassic	Phra That	Turbidite	Bivalves(Halobia, Daonella,Posidonia) Ammonites(Trachyceras, Joannite)	Shallow marine near-off shore neritic	Strong extension tectonics,high angle subduction,rapid subsiding basin	third stage
M L Triassic	Doi Long	Grey micrite	Bivalves(Trigonodus), corals, crinoids gastropods	shallow water, near shore, drown ramp platform	Chiang Rai -Lampang close to Shan-Thai, basin nearly close	Late stage
L Triassic	Pha Daeng	Red beds	no	Fluvial deposit, land derived	Continental collision, A-subduction.S-type gr.	Closure stage

subarkose. The younger, Ban Pong Pak member includes grey shale and interbedded light brown mudstone in the lower part (Figure 3E), green shale intercalated with pale green calcareous greywacke and intraformational conglomerate in the middle, and brown mudstone interleafed with minor limestone beds and lenses. Fossils include benthic bivalves (*Costatoria* sp., *Eopecten* sp., *Mysidioptera* sp., *Pteria* sp. , *Entolium* sp.), which indicate the age of early Scythian (early Early Triassic) to early Anisian (early Middle Triassic) (see Supananthi, 1993).

The Pha Khan Formation, the second unit with thickness of 500 m, is widely exposed as karst towers (Figure 3G) in the southern part. This rock unit can be subdivided into 2 members, namely Huai Pha Chi member, the older unit, including biosparite to oolitic (Figure 3H) limestones with intercalated calcareous mudstone, shale and protoquartzite in the lower part, and Doi Pha Tub member, the younger, comprising biomicritic, oncolitic and bio-clastic limestones. Abundant fossils are found including bivalves (*Hoernesia* sp. and *Elegantinia* sp.), corals, algae, brachiopods, and ammonoids. The age based on paleontological evidence is Anisian (early Middle Triassic) to Carnian (early Late Triassic).

The Hong Hoi Formation includes 1,350 m-thick turbidite sequence. This stratigraphic unit which is the most widely distributed, can be divided into Huai Hok, Huai Mae Dam, and Huai Long members, the first being the oldest. The Huai Hok member comprises grey to greenish grey laminated mudstones with spheroidal fractures (Figure 3K), interbedded with thinly bedded, grey protoquartzites and siltstones. The Huai Mae Dam member comprises greyish brown greywackes grading to conglomeratic sandstones in the upper part, and thinly bedded limestones are locally intercalated. The youngest, Huai Long member is characterised by grey to greenish calcareous mudstones with brown greywackes and lenses to small beds of allodapic limestone. The Hong Hoi Formation contains characteristic faunal assemblage of ammonoids (Figure 3L, *Joannites* sp., *Trachy-*

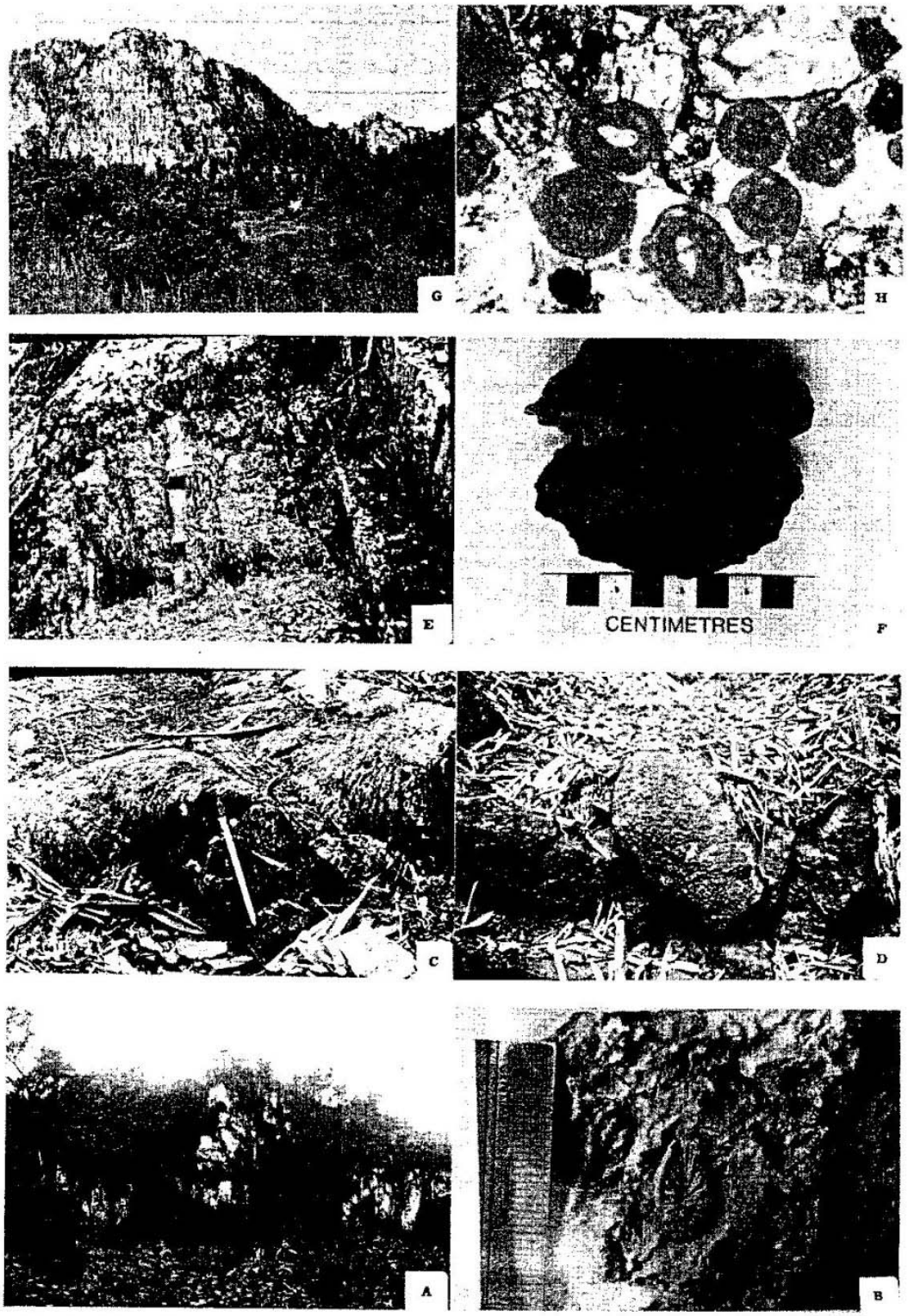

Figure 3. A. Natural exposures of carbonate rocks at Doi Pha Kot, Pha Huat Formation, Ratburi Group, showing karst tower (looking SW). B. Hand specimen of grey limestone showing rugose coral, Pha Huat Formation, Doi Pha Kot. C. Stream-cut exposure of dark grey slaty shale of the Huai Tak Formation, Ratburi Group (grid 945333). D. Loose blocks of volcanic agglomerates, nearby Nam Mae Man, showing abundant and variously-sized fragments. E. Road-cut exposure of mudstone alternated with shale, Phra That Formation, Lampang Group. Noted that a well-bedded protoquartzite on the right. F. A hand specimen of brown mudstone showing *Daonella* sp., Hong Hoi Formation, Lampang Group. G. A karst topography of Triassic limestone at Doi Pha Kan, Pha Kan Formation, Lampang Group (looking west). H. Photomicrograph of sparite limestone showing oolitic texture, of Huai Pha Chi member, Doi Long Formation.

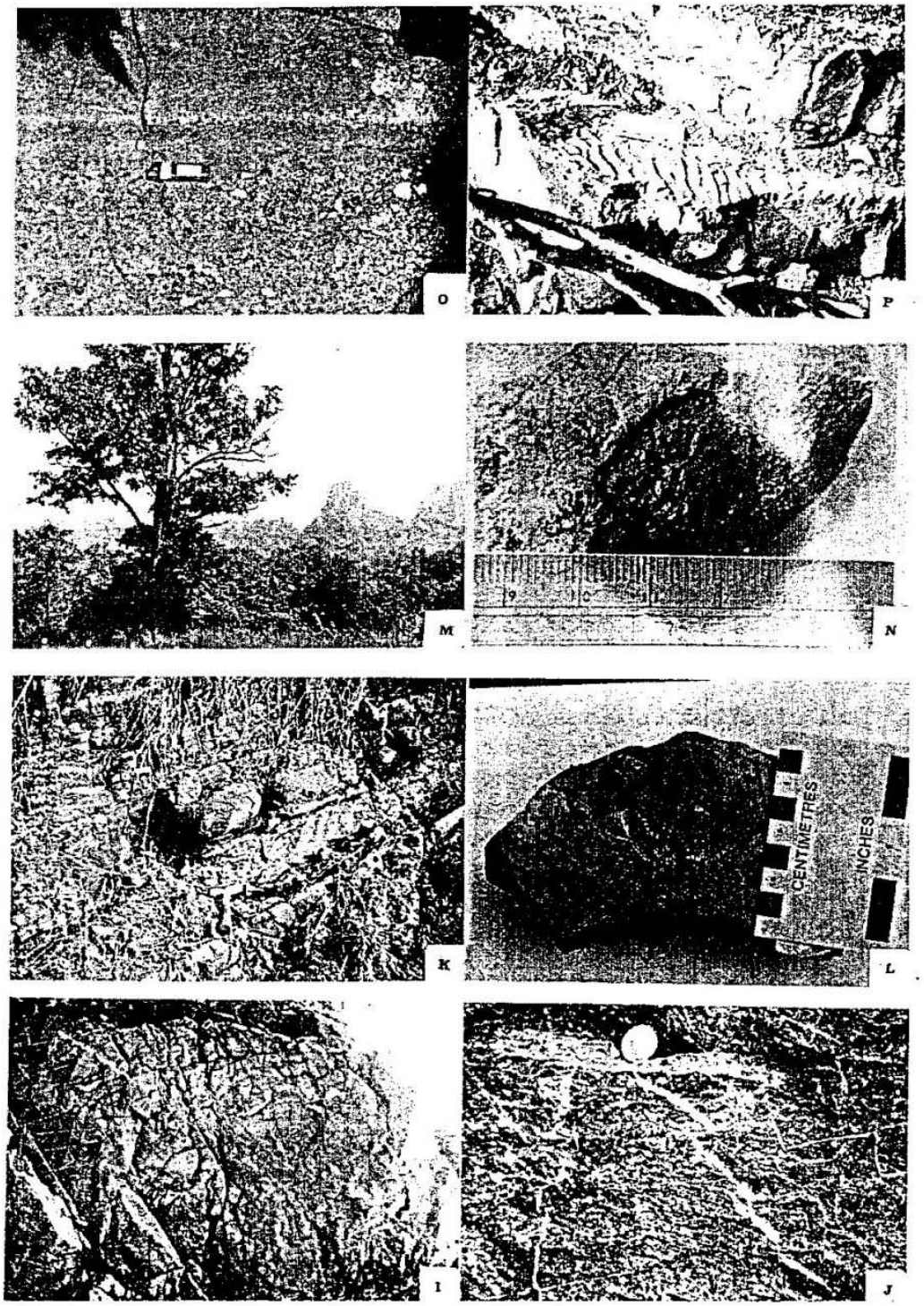

Figure 3. (Continue) L A natural exposure of Triassic limestone at Doi Pha Kan Formation, showing en échelon-gash veins, indicating deformation event (view looking SW, photo not in the right side-up. J. A close-upview of dark grey micrite limestone, Pha Kan Formation, showing an en échelon structure (looking west). K. An alternating sequence of spheroidal mudstone interbedded with shale (top beds) and proto-quartzite (bottom beds), Hong Hoi Formation, Lampang Group. L. Hand specimen of allodapic lime-stone containing ammonoid of the Hong Hoi Formation, Lampang Group. M.View of Doi Huai Long at which the type section of limestones of the Doi Long Formation, Lampang Group, are located (taken to east). N. Hand specimen of micrite limestone, showing an ammonoid of the Doi Long Formation. O. A stream-cut exposure of polymictic conglomerate grading upward to conglomeratic protoquartzite and reddish brown sandstone, at Doi Pha Daeng, of Pha Daeng Formation. P. An exposure of light brown grey sandstone interbedded with mudstone, the latter showing asymmetrical ripples, stream paleocurrent to the east, Pha Daeng Formation.

ceras sp. , and *Paratrachyceras* sp.), bivalves (*Daonella* sp., *Posidonia* sp., *Entolium* sp. , and *Halobia* sp.). The paleontological age dating gives rise to Carnian to Norian (early to late Late Triassic).

The Doi Long Formation is composed predominantly of lithographic, biomicritic to bioclastic limestones with dolomite and scattered yellowish brown mud patches. The unit contains several index fossils, such as bivalves (*Trigonodus* sp.), serpulid worms, brachiopods, algae, corals, ammonoids (Figure 3N) and crinoids. In some parts the unit unconformably overlies the Hong Hoi Formation and can be transitional as facies change to the Hong Hoi in the other parts (Supananthi, 1993). The unit is locally found as NE-trending conspicuous karstic towers (Figure 3M), usually with high-angle dipping.

The Pha Daeng Formation, the youngest, 850 m thick, nonmarine unit of the Lampang Group, occurs only in the restricted area to the northwest. The unit can be subdivided into 5 clastic members, namely Huai Da Noen, Mae Wang Wua I, Mae Wang Wua II, Rong Pa Taeu, and Doi Kham Phra. The Da Noen member is characterised by grey to red basal limestone, polymictic orthoconglomerate and conglomeratic sandstone with good cementing and moderately sorting texture and clasts of volcanics, limestones, and clastics. The Mae Wang Wua I member consists mainly of red siltstone interbedded with well-bedded, red arkose, grey to red conglomeratic protoquartzite and paraconglomerate (Figure 3O). Cross-bedding (up to 2 m long) is quite common in coarser-grained clastics. The Mae Wang Wua member includes grey protoquartzite, red subarkose with intercalated red siltstone. The Rong Pa Taeu member is red to grey, calcareous and/or micaceous mudstone interbedded, in some places, with thinly bedded siltstone. Micro cross-bedding (up to 4 cm) and medium-scale ripples (Figure 3P) are quite common sedimentary structure. The Doi Kham Phra member, the youngest unit, is characterised by red to reddish brown, cross-bedded, paraconglomerate and reddish brown protoquartzite.

STRUCTURES

The Ban Thasi rocks have experienced several episodes of deformation. They were folded in to a series of NE-trending syncline and anticline. The large and roughly symmetrical syncline with high-angle dipping and NNE trend, plunges due N with a fold axis of 10-20°. The syncline is found in an area surrounding the Pha Daeng Formation. A small anticline of similar trend is observed in the NW where the Permo-Triassic are predominated. Both syncline and anticline are subsequently dissected by at least two sets of faults. Enhanced LANDSAT and SPOT image interpretation (Charusiri and Galong, 1994) together with field (Figures 3J&K) and petrographic studies (Supananthi, 1993) indicate the existence of NE-trending faults. The other anticline whose axis is in the Permian sequences, is that observed in an undulating terrane to the east. It has the NNE trend and is later cut by the N-trending faults. Among the faults detected, the NE-trending fault in areas dominated by the Hong Hoi Formation in the central part of the study area, seems to be the most spectacular. The fault is determined using combined air-borne, image and geophysical interpretation. Galong and Charusiri (1994) visualise, based upon enhanced airborne geophysical data, that the basement of the Ban Thasi has undergone somewhat tilting to the east and almost the whole area has subject to tectonic activity with some degree of alteration - related to unexposed plutonism.

DISCUSSION ON TECTONIC EVOLUTION AND PALEOENVIRONMENTS

Judging from the currently afore-mentioned information and the previous geological studies, paleoenvironments coupled with related tectonism are proposed herein. The geological information of the Ban Thasi area is summarised in Table 1. It is likely that all the sedimentary strata were deposited in the so-called Lampang - Phrae Basin (Figure 4; Chaodumrong and Rao, 1992; Chonglakmani and Grant-Mackie, 1993). The evolution of the basin can be divided into 6 stages below.

1. ONSET OF LAMPANG BASIN (PRE-PERMIAN

The ground preparation of the basin developed during Middle to Late Permian. The study area is inferred to be situated at the eastern-most margin of the Shan Thai microcontinent. Supananthi (1993) advocates the study area located within an exotic terrane which may have

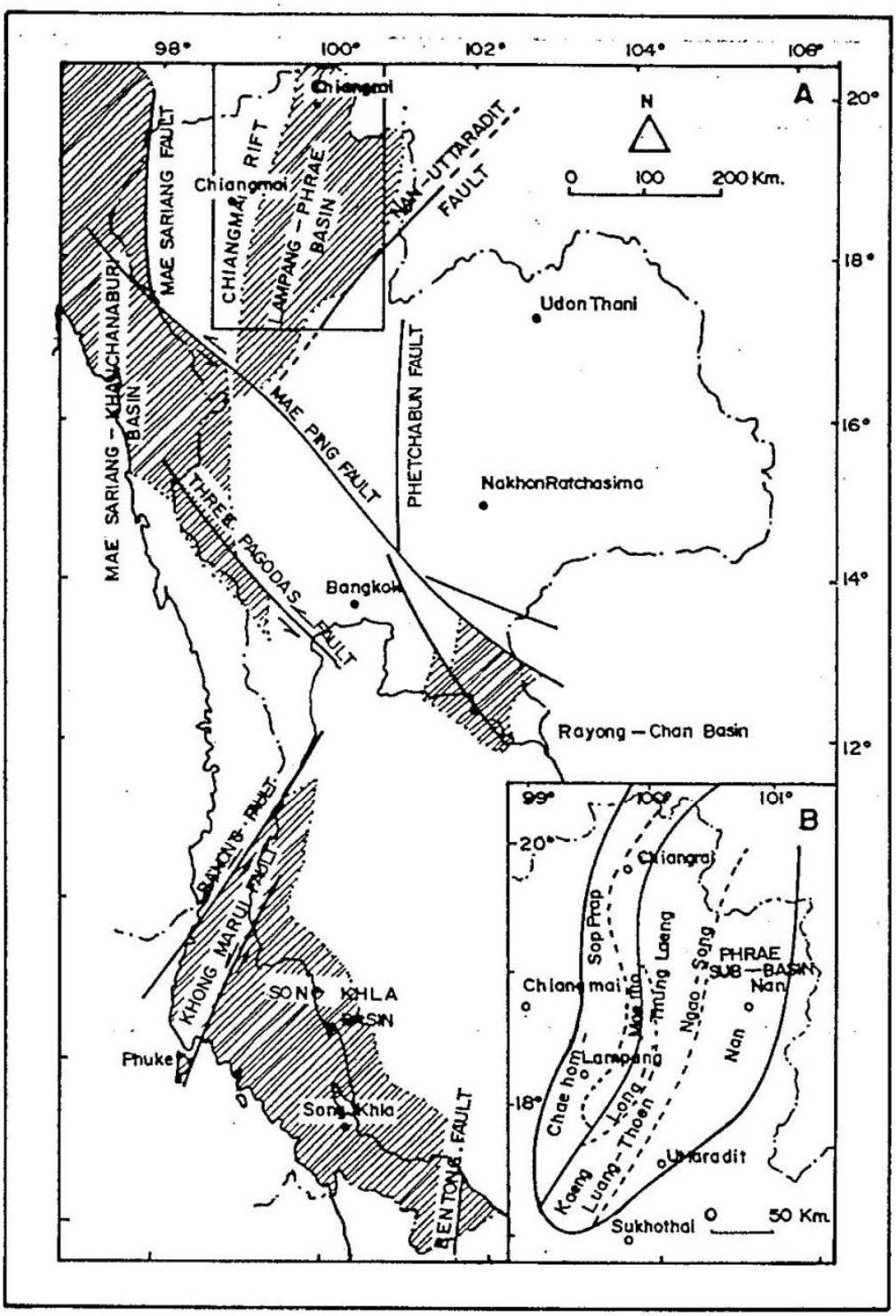

Figure 4 Distribution of Triassic basins in Thailand, an insert map showing the location of the Lampang Basin.

been mostly underlain by Devonian-Silurian volcaniclastics (Bunopas, 1981) with minority of inferred Precambrian Chiang Rai gneiss (Charusiri, 1989). This terrane is called herein as Chiang Rai-Lampang block, has a close relationship, and bears some features similar to the Shan-Thai. Chiang Mai back arc rift is believed to represent a boundary between two continental blocks. The Chiang Rai-Lampang block is marked by the Nan-Uttaradit geosuture (Mitchell, 1986; Barr and Macdonald, 1987) to the east and the Chiang Mai geosuture (Cooper *et al.* , 1989) to the west.

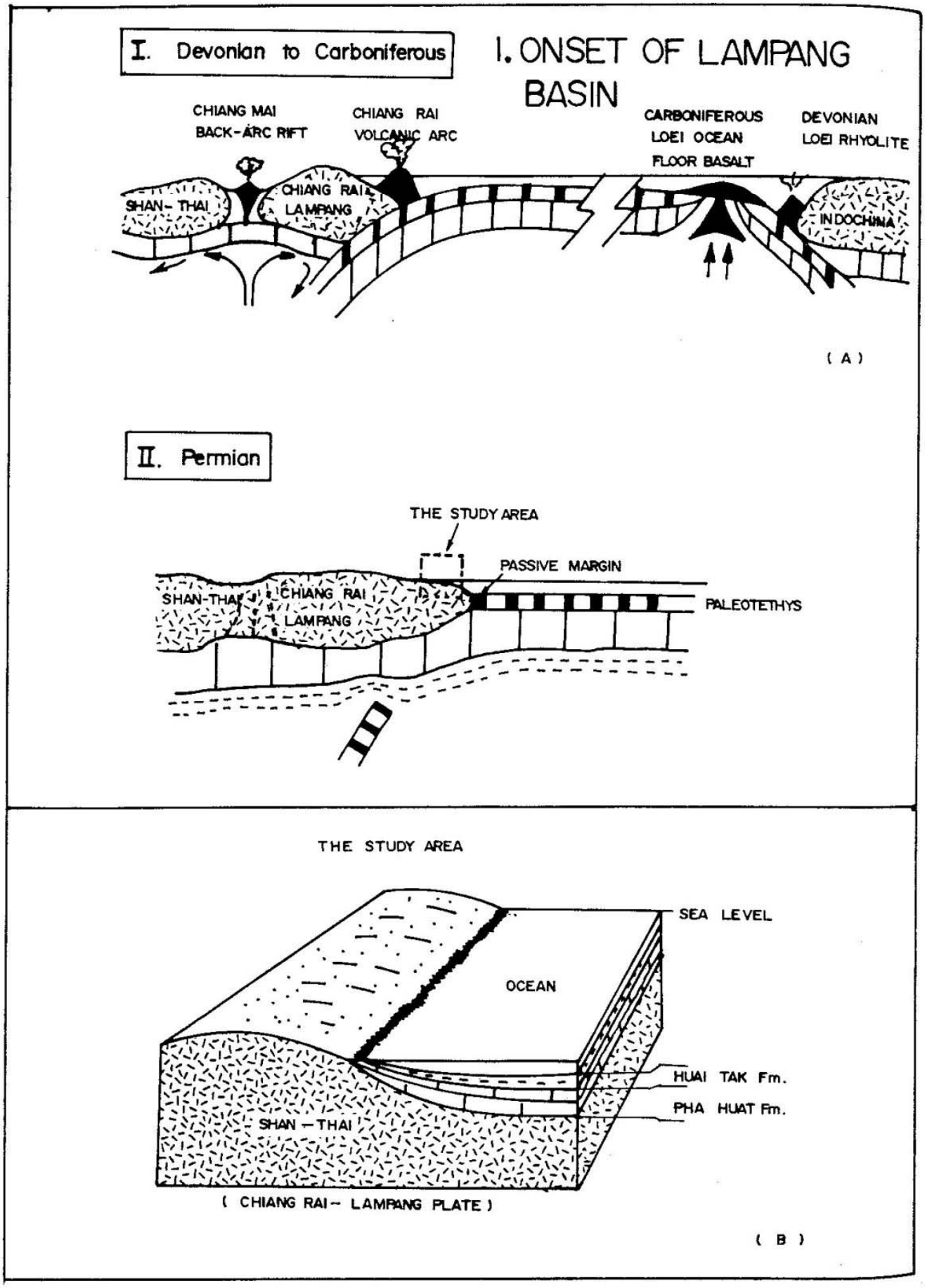

Figure 5. Reconstruction of the Lampang basinal evolution, (A) Tectonic setting and (B) Paleoenvironment, 1. Onset of Lampang Basin (Permian and older);

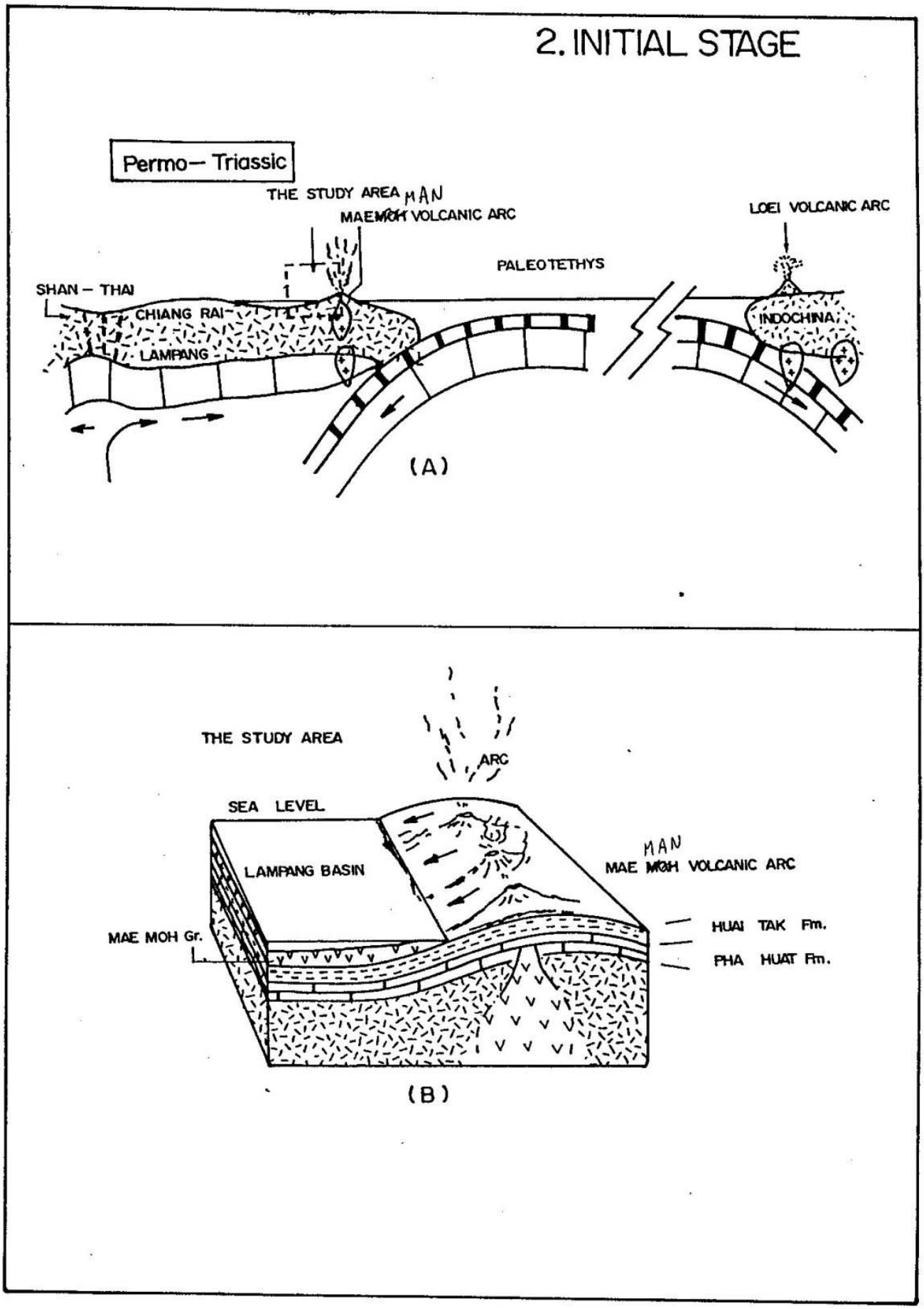

Figure 5. (continue), 2. Initial stage of basinal development (Permo-Triassic);

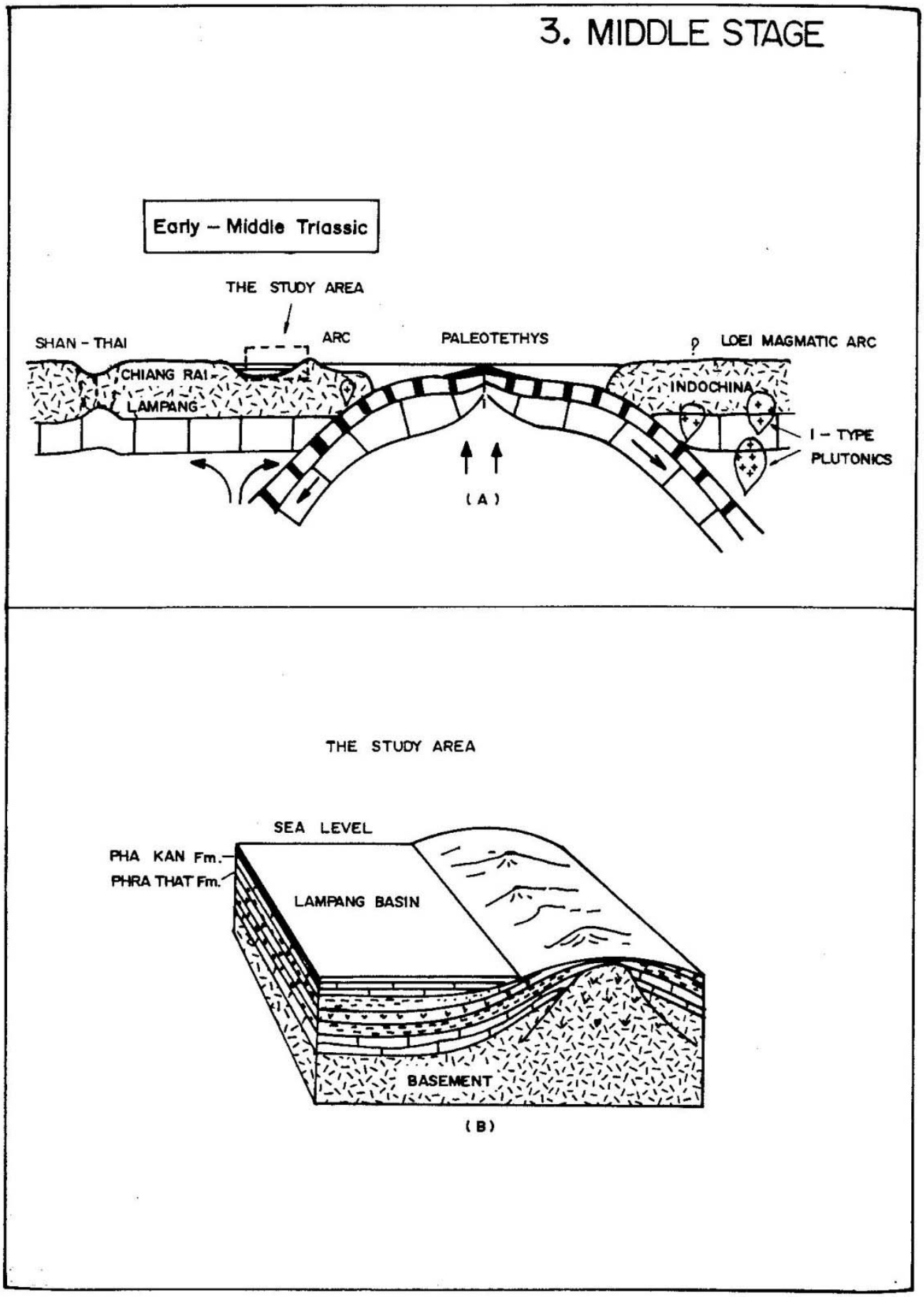

Figure 5. (continue), 3. Middle stage of basinal development (Early Triassic);

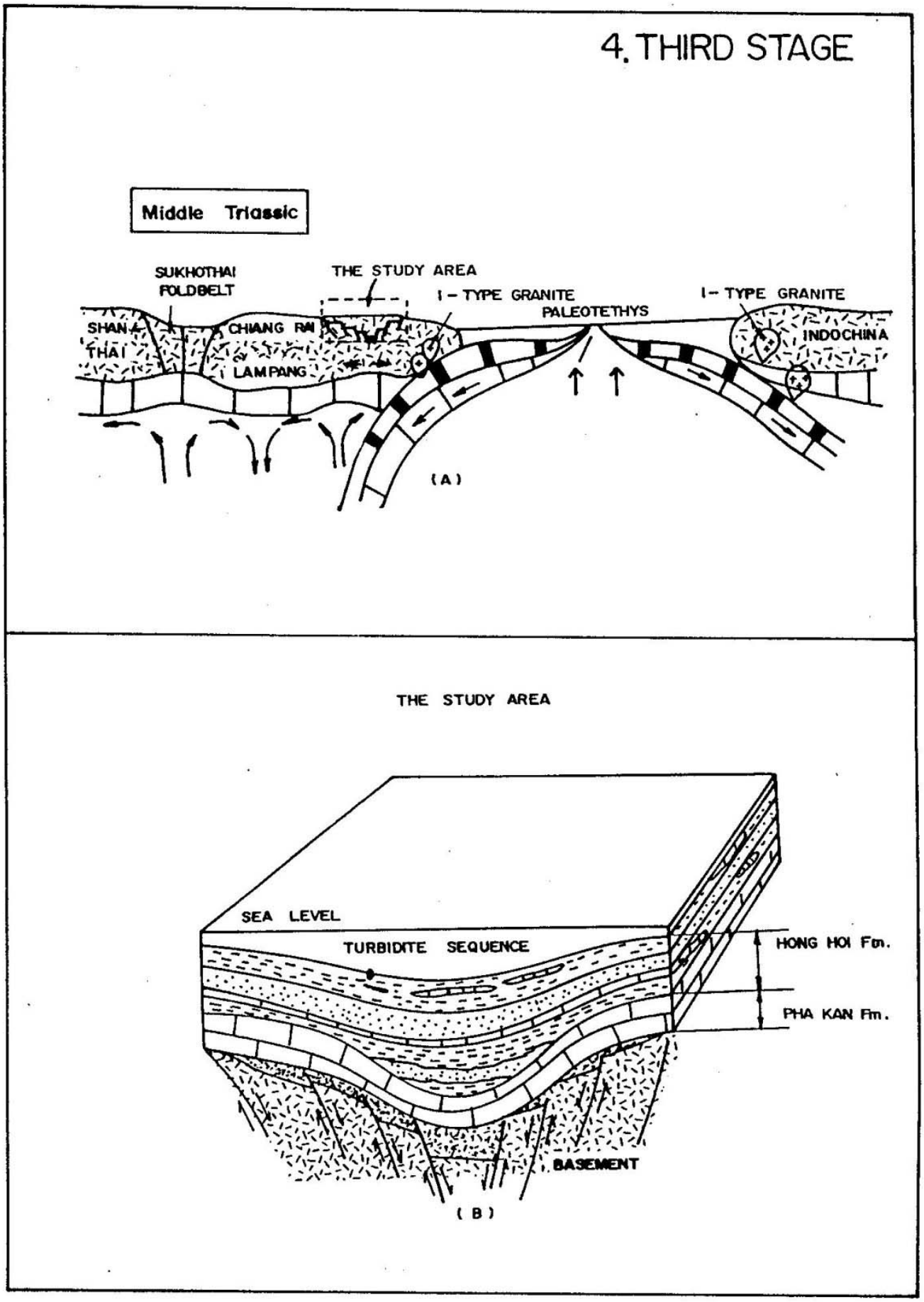

Figure 5. (continue), 4. Third stage of Lampang Basin (Middle Triassic);

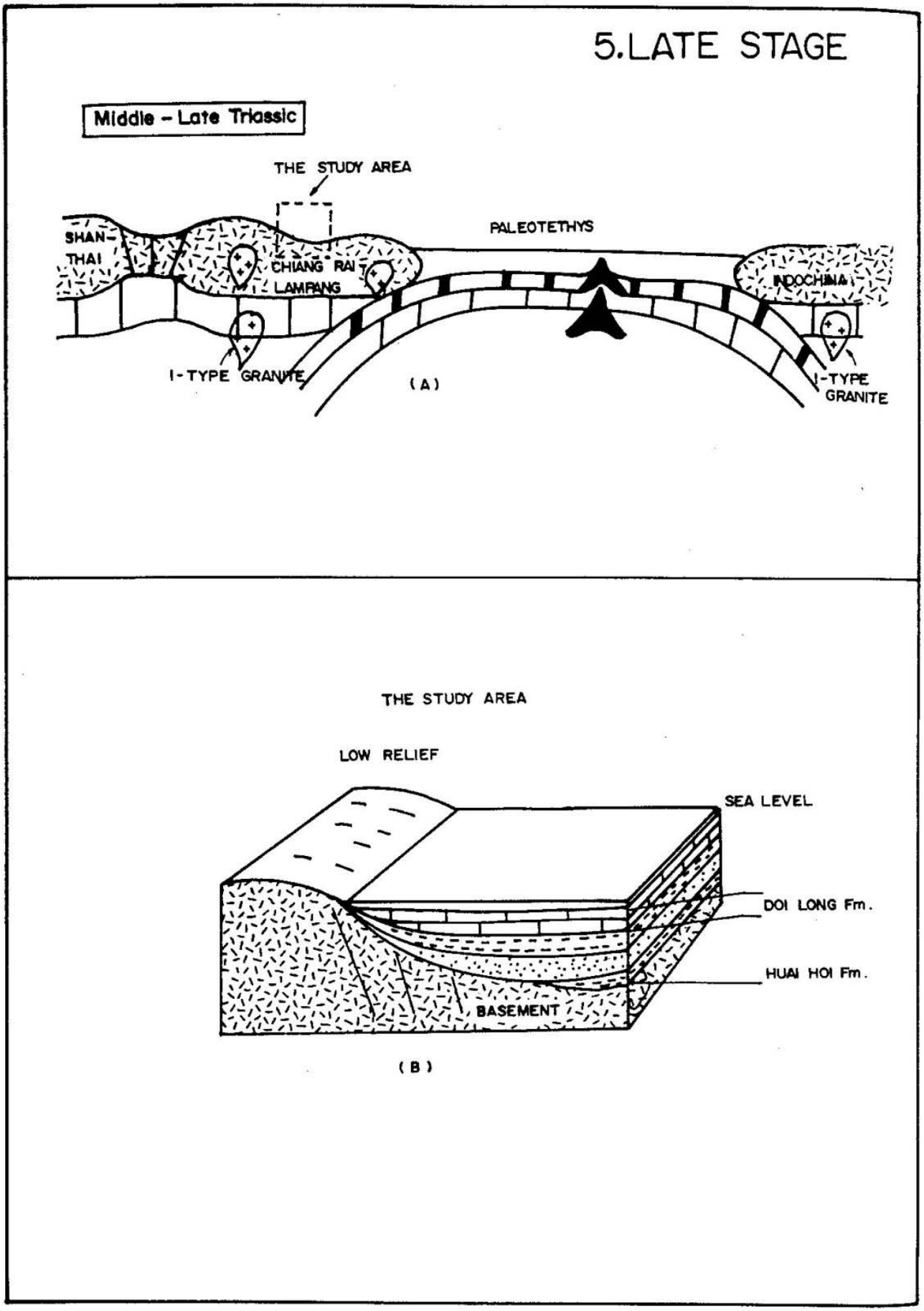

Figure 5. (continue), 5. Late stage of Lampang Basin (Middle-Late Triassic); and

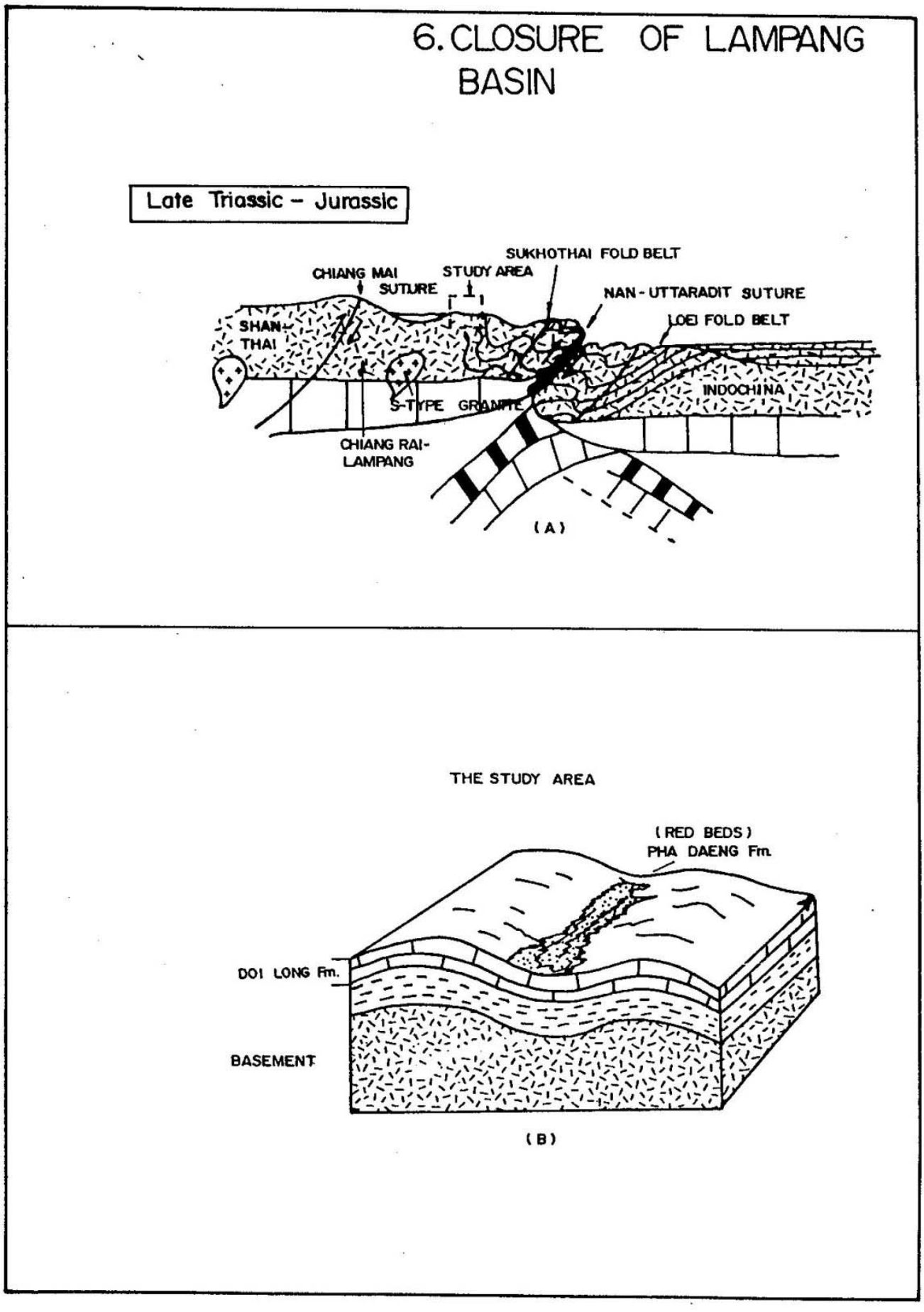

Figure 5. (continue), 6. Closure of Lampang Basin (Late Triassic-Early Jurassic).

Both lithological and paleontological evidences for the Permian Pha Huat marine strata advocate the depositional environment of quiet, stable, mud-deficient condition and lack of prominent terrigenous sediments. Such environment may have formed along the passive continental margin of the Chiang Rai-Lampang block (or the easternmost edge of the Shan-Thai, see Figure 5-1A). The absence of voluminous terrigenous sediments indicates low-relief landmass or topography with gentle slopes immediately adjacent to the basinal margin (Figure5 1B). Such features can obstruct the turbidity of sea water and generate only small amount of land-derived sediments. The paleoenvironment of clear, warm- and shallow-marine depositional condition has been confirmed by the presence of *Neoschwagerina* sp. , *Fenestella* sp. , and corals (Piyasin, 1972). The nature of benthic and pelagic fusulinids strongly support the open-sea and sea-floor environments. Therefore, we interpret that the Middle to Late Permian paleoenvironment is most likely to be tropical, shallow-marine open sea.

However, during the Late Permian, depositional environment was modified due to the advent of terrigenous sediment influx. The condition favourable for the occurrence of fragmental brachiopods, bryozoans and pelecypods. It is probable, therefore, that the sediments were deposited in the shallow-marine shelf with more unstable and higher energy condition.

2. INITIAL STAGE OF BASIN DEVELOPMENT (PERMO-TRIASSIC)

Towards the end of Permian, W-dipping subduction was initiated beneath the Chiang Rai-Lampang (or Shan-Thai) block in addition to the NE-dipping subduction beneath the Indochina block (Figure 5 2A), causing a paired subduction Benioff zone. Rate of lithospheric divergent movement was possibly high, giving rise to the Paleotethys oceanic slab subducted rapidly beneath both continental plates and in turn, developing Mae Man and Loei volcanic facies (Figure 5 2B) as well as the emplacement of subduction-related, I-type plutonics (Charusiri, 1989).

After the convergence of the Chiang Rai-Lampang and Paleotethys oceanic plates, primitive Lampang Basin was formed at the eastern margin of the Chiang Rai-Lampang block. The basin, then, marked the western margin of the volcanic arc. The N-trending extrusion of subduction-related volcanic facies may have acted as barrier islands which controlled morphology of the N-trending, lagoon-like, elongate basin.

3. MIDDLE STAGE OF BASIN DEVELOPMENT (EARLY TRIASSIC)

In the first episode of this stage, depositional environment of the study area is believed to be a shallow marine basin as characterised by the occurrence of volcanic-derived clastic sediments deposited onto the passive continental margin (Figure 5 3A). These Phra That epiclastics are referred to have been derived from the provenance eastward; i. e. the emergent Mae Man volcanic terrane (Figure 5 3B) as a result of the continuing subducting plate.

In the second episode, topography of the arc terrane to the west became low-relief and gentle-slope since emergent volcanic terrane had been rapidly eroded. Such circumstance gave rise to both clastics and carbonates deposited in the rifted-generated back arc basin onto the ongoing active continental margin. The alternation of grey and red clastic sequences may indicate either fluctuation of water depth in the basin or the short period of emergent basin. However, the appearance of large and thick-shelled benthic bivalves without ammonites of the Phra That clastics, definitely suggest the near-shore, neritic, inner shelf environment.

During the last episode,the environment of deposition is marked by back-arc type shallow marine, as evidenced by the abundance of oncolites, bivalves, brachiopods and corals. Pha Kan biomicrite and biosparite are regarded to have been deposited in the ramp (and/or drowned ramp) platform, a gently-sloping platform, on the basis of a lack of continuous barrier-reef and fore-reef deposits, implying an absence of a marked break in slope. The occurrence of oncolites and the destitution of turbidites and slump structures strongly support the gentle slope of the carbonate ramp. This interpretation is rather similar to that of Chaodumrong and Rao (1993) who also advocate that the deposit might have taken place in an elongated, possibly protected, and restricted depositional basin.

4. THIRD STAGE OF LAMPANG BASIN (MDDLE TRIASSIC)

In this stage the Shan-Thai almost collided with the Indochina, and the rift due to convection-induced uprising mantle plume may have been developed in the Chiang Rai-Lampang plate, giving rise to a rapid subsidence of the basin and causing the deposition of the Hong Hoi deep marine strata (Figure 5 4A). Such rapid subsidence of some areas were compensated with the uplifted of the others to accommodate the balanced section of the lithospheric plate experienced extension tectonics. Fault-controlled, alternating high and low reliefs of the Lampang Basin (Figure 5 4B) reflect the structural grains similar to those of the Basin and Range of the SW U. S. A. (see Cooper *et al.* , 1989). The fauna fossils including ammonoids (*Paratrachyceras*, *Trachyceras*, and *Joannites*) and bivalves (*Posidonia* and *Daonella*) point to the deep sea environment. Chonglakmani and Helmcke (1989), however, point out a magnificent support that the Hong Hoi grey facies was deposited in a shallow marine basin apparently under poorly aerated condition, as indicated by bioturbation and worm tubes in laminated fine-grained clastics. In addition, the Hong Hoi alternated grey and red facies along the Ngao-Song Highway are possibly believed as a transition in conditions from marine to nonmarine environments (Macdonald, 1978). Therefore, we interpret that the Hong Hoi sediments were deposited as turbidite sequences in the relatively shallow marine environment within a subsiding basin. Mutual association of ammonites with pelagic bivalves suggests a more off-shore environment. It is quite likely that high-angle dipping and high rate of subduction may have accounted for this fault-induced subsidence.

The pronounced vertical facies changed from Pha Kan platform carbonates to Hong Hoi clastic turbidites, indicating an essential increase in the amount of land-derived materials being deposited. This was possibly caused either by the relatively high relief of the land areas surrounding the basin or by the rise of sea level as a result of the fault-controlled subsidence.

5. LATE STAGE OF LAMPANG BASIN (MIDDLE TO LATE TRIASSIC)

Subduction of oceanic Tethys beneath the Chiang Rai-Lampang block was still in progress (Figure 5 5A) but gradually slow. As a result, cessation of violent basinal subsidence occurred, and consequently the marine environment had changed from relatively deep to normal shallow marine condition. The turbidite deposits were, later on, replaced by Doi Long carbonate facies. As the basin became shallower and less subsided in some part, the water become more mud-free and without large supply of terrigenous sediments. This possibility also suggests low relief of the land areas nearby (Figure 5 5B). The occurrence of the light grey, relatively pure limestones possibly indicates a rather oxidising environment of the ramp platform, distant from siliciclastic influx. The disappearance of reefal-facies limestones may also suggest the platform surrounded by shallow sea. Varieties of faunas, e.g. corals, algae, gastropods and particularly fragmental bivalves (*Trigonodus* sp.), confirm the shallow-water, near-shore and high energy condition of littoral-zone environment.

6. CLOSURE OF LAMPANG BASIN (LATE TRIASSIC-EARLY JURASSIC)

Transition from the Doi Long drown ramp carbonates to Pha Daeng red-bed clastics also indicates an outstanding sea level change. Two possible consecutive steps and, in fact, the controlling factors need to be involved in the termination of the Doi Long carbonates. These include a continual uplift of the platform and landmass, and subsequent voluminous influx of detrital clastics. However, Chaodumrong and Rao (1992) argued that the lack of evaporite and beach deposits advocate the latter condition. The appearance of oligostrome or structural conglomerate containing a great deal of large-sized carbonate phenoclasts supports the tectonic-controlled uplifted platform. The overlying red beds within the Ban Thasi Syncline (Figure 5 6B) imply the subaerial deposition, a suggestive of a strong oxidising environment formed by fluvial process.

During the final stage, tectonic setting was characterised by the continental collision between Chiang Rai-Lampang (or Shan-Thai) and Indochina blocks (Figure 5 6A), causing A-type subduction zone and S-type granitoids (e. g. Khuntan Batholith). The Lampang Basin was totally uplifted, and becoming emergent landmass. The Doi Long and Pha Kan carbonates were severely eroded, forming limestone conglomerates of the lower Pha Daeng facies.

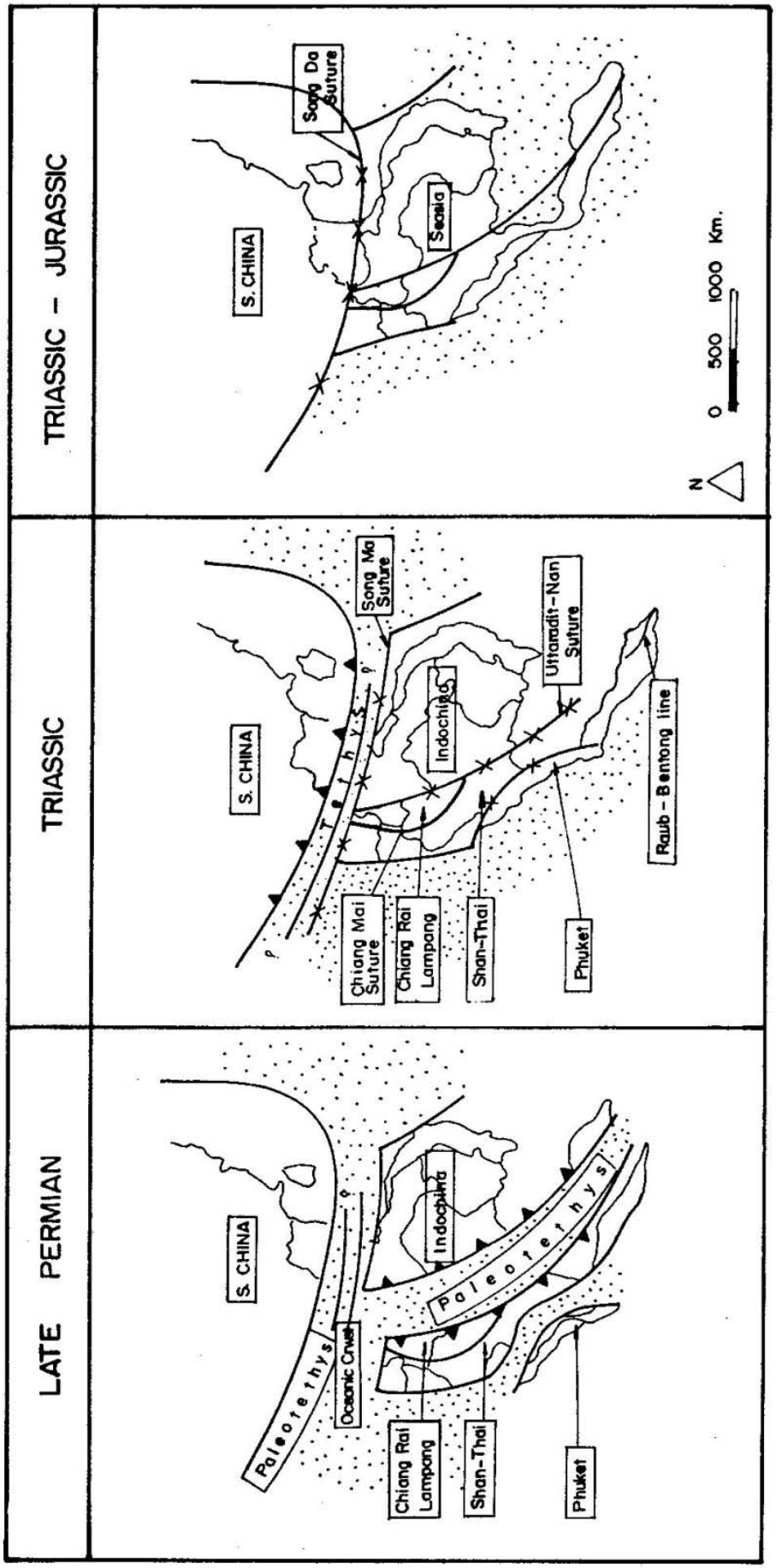

Figure 6. Plate reconstruction of mainland SE Asia, showing five exotic terranes and location of Chiang Rai-Lampang block, during Permian to Jurassic Periods.

Obvious N- and NE-trending faultings in the area may have caused a rapid influx of land-derived siliciclastic materials, equivalent to the red beds of the mollasse-type Khorat Group in NE Thailand.

TIMING AND TECTONIC SCENARIO OF LAMPANG BASIN

Timing of the Lampang (- Phrae) Basin is quite disputable, whether the basin was formed contemporaneously with the Nan Uttaradit suture and obduction of ophiolite sequences during Triassic (Bunopas, 1981; Mitchell, 1986; Sengör, 1986; and Charusiri, 1989) or during Upper Paleozoic (Helmcke and Lindenburg, 1983; Chonglakmani and Helmcke, 1989) is quite intricated. Sengör (1986) proposed that the Triassic truely deep-marine, flysch-type sediments were deposited in the pre-collision, fore-arc, basinal environment. This implies that if there was a SW-dipping subduction beneath the Chiang Rai-Lampang block, the basin should have become deeper and deeper to the east. Yanagida (1988) noted that the Upper Triassic corals near Huai Rong Sak to the east outsidethe study area, close to the Nan-Uttaradit suture, strongly confirm the shallow marine condition. This also implies that the Lampang Basin is not a fore-arc basin of deep marine flysch sediments. However, the Triassic pre-collision tectonic setting is favoured for the basin development. Such period of time is markedly contrast to that proposed by Chonglakmani and Helmcke (1989) for the post-collision setting. That the shallow-marine, mollasse-type, back-arc basin has been formed as a result of Tethys subduction beneath the Chiang Rai-Lampang block prior to the Triassic continental collision, is quite more acceptable (see also Figure 6).

CONCLUSION

The paleoenvironments and associated tectonic settings of the Ban Thasi area can be interpreted, based upon new stratigraphy, field and paleontological criteria, enhanced space-borne images and geophysical data, as well as petrographic analysis. All the rocks were deposited in the tectonic Lampang (-Phrae) Basin in the Chiang Rai-Lampang continental block nearly attached to the eastern margin of Shan-Thai (Figure 6). The Permian Ratburi carbonates may have occurred in the open marine shelf of the passive continental margin. Later, arc-type volcanics and volcaniclastics were formed as a result of NW-dipping subduction of paleotethys oceanic slab beneath the Chiang Rai - Lampang block. Then deposition of the Phra That epiclastics occurred in the shallow-marine shelf basin enclosed by emergent volcanic terrane. Deposition of the Pha Kan nonclastic sediments may have taken place in the shallow-marine basin. Later on, the basin may have been subsided rapidly as a result of the Chiang Rai-Lampang/Shan-Thai became closer, and the deposition of the Hong Hoi turbidites developed. Doi Long non-clastics was subsequently deposited in the shallow marine basin. During Late Triassic-Jurassic, the Shan-Thai and the affiliated Chiang Rai - Lampang blocks may have collided with the Indochina block, and the basin may have been uplifted. As a result, the Pha Daeng, mollasse-type, clastic red beds may have formed as nonmarine sediments either in the uppermost part of the Lampang Group or parts of the Khorat Group.

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