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The welding of Shan-Thai

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ABSTRACT: The Shan-Thai Terrane is viewed as a remnant of paleo-Tethys in South East Asia. The more internal "Thai" elements of Shan-Thai, bordering with Indochina, are of Cathaysian type, while the more central part of the terrane is of transitional "Sibumasu" character. The external "Shan" elements of Shan-Thai that left Gondwana last have a clear cold-water imprint. Petrological and paleontological evidence corroborates the end Triassic – earliest Jurassic Late Indosinian orogeny, as the main Paleotethyan tectonic closure event. Its main axis consists of the Mae-Sariang Zone, which can be followed over Mae Sot to Kanchanaburi and Chanthaburi, from where it extends into southern Thailand and Peninsular Malaysia. Cenozoic Himalayan escape tectonics, alternating strike-slip movements and rotation severely compressed Shan-Thai, opened the Gulf of Thailand, disrupted the original alignment of the Mae Sariang zone and Gondwana-Tethys divide, and shaped the present tectonic configuration of SE Asia.

Key words: Indosinian orogeny, paleo-Tethys, Shan-Thai, Mae-Sariang Zone, Gondwana-Tethys Divide

1. INTRODUCTION

Facing the complex concept of Shan-Thai calls to mind the question whether Shan-Thai represents a terrane (e.g., Burrett et al., 1990), a block or micro-continent, composed of several small terrane units (Chonglakmani, 2002; Bunopas et al., 2002). Is the term "Sibumasu", used by several authors (Nie et al., 1993; Metcalfe, 1998; Hada et al., 1997), just a synonym of Shan-Thai, or does it design the paleo-latitudinal transitional faunal province that characterizes part of Shan-Thai during Permian times (Shi and Archbold, 1998)? How many smaller tectonic elements constitute Shan-Thai? When did the welding of Shan-Thai with Indochina take place and where does this fit within the concepts of Indochina orogenies and the closure of paleo-Tethys? Our geological observations in Western Thailand (Mae Sot/ Umphang, Tak Province) provide a number of clues that we try to integrate into the wider spectrum of Shan-Thai (e.g., Ishida et al., 2006).

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2. ELEMENTS OF SHAN-THAI

2.1. General Consensus on the Paleogeographical Setting

The paleo-Tethys was a poly-island oceanic system (Liu et al., 1993), also called archipelagic (Yin et al., 2004). It consisted during the Paleozoic and Early Mesozoic of northwards drifting terrane-elements that rifted from the Gondwana margin, leaving freshly opened oceanic branches behind. In early Permian times, the elements composing South China, Indochina and internal parts of Shan-Thai had not yet docked with Laurasia and the most external Shan-Thai elements were barely detached from Gondwana. Among the first waves of these slivers, the more internal elements of Shan-Thai were brought alongside Indochina by the closure of older ocean branches that are now marked by sutures like the one of Nan-Uttaradit (Sengor, 1979; Stocklin, 1980; Barr and McDonald, 1987; Scotese and Golonka, 1992; Metcalfe, 1990a). Successive waves of northwards moving Shan-Thai elements reached the lower paleolatitudes of the Sibumasu facies-realm (Shi and Archbold, 1998). This considerable ocean space thus originally divided the internal "Laurasia" elements from the external "Gondwana" elements. It encompasses a set of intermediary or "Sibumasu" elements, the limit of which with the external elements presently constitutes the *Gondwana -Tethys Divide* (Ueno 1999; Wang et al., 1997). For Charusiri et al. (2002), a Nakhon-Thai ocean floor and a Lampang-Chang Rai volcanic arc intervened between Shan-Thai and Indochina during the Middle Paleozoic. Boucot (2003) discussed masterfully the ambiguity of some of the biotic links of these elements to Gondwana and Eurasia, broadly assuming the integrity of Shan-Thai, as well as suggesting an eventual Late Devonian to Early Carboniferous pre-Indosinian amalgamation of some of the blocks composing Shan-Thai, after they had moved independently for some time.

2.2. The Indosinian Orogenies

The welding together of the terranes forming SE Asia took place during several Late Paleozoic-Mesozoic Indosinian orogenies. These encompass for Fontaine and Workman (1978) latest Permian – Triassic and Late Triassic – Early Jurassic phases, the latter being also known as the Thai-Malay or Malay-Yunnan orogenies. Estimations of the timing of the earliest docking of Shan-Thai vary from late Middle Permian (Helmcke, 1985) to Latest Permian -Early Triassic (Cooper et al., 1989; Metcalfe, 1990a, 1991), Late Triassic (Ridd, 1980; Bunopas, 1981; Sengor et al., 1988; Dheeradilok et al., 1992; Sashida and Igo, 1999; Charusiri et al., 2002; Boucot, 2003) or Early Jurassic (Mitchell et al., 2002). For Sashida and Igo (1999), Shan-Thai and East Malaya collided in Early Triassic. For Barr and McDonald (1991), the Sukhotai terrane, located between Shan-Thai and Indochina, accreted to Indochina in the Middle Permian, while Shan-Thai followed in the Late Triassic.

For Charusiri et al. (2002), the amalgamation of the Shan-Thai, Lampang-Chang Rai and Nakhon-Thai blocks with Indochina, as well as the termination of paleo-Tethys resulted from the Late Triassic collision of all terranes and thrusting. The respective thrust planes correspond to the Chang Mai, Nan and Loei sutures (Fig. 1).

2.3. Subdivision of SE Asia and the Proposed Concept of Shan-Thai

A satellite picture from space, may suggest the tectonic subdivisions of SE Asia (Nie et al, 1993). All major sutures of SE Asia seem to pass through the narrow 200 km wide bottle neck of western Yunnan, opening like a fan into Thailand (Wang et al., 1997, Fig. 1, p.106). In their review paper, these authors have summarized their SE Asian plate-tectonic interpretation of western Yunnan and northern Thailand. Ueno (1999) and Chonglakmani et al. (2001) have differentiated several tectonic - stratigraphic units that run from Yunnan into Thailand.

In our proposed concept, the SE Asian area is subdivided into the following tectonostratigraphic terranes (Fig. 2), with reference to the Permian and Triassic facies (Table 1):

The **Yangtse-Indochina border zone:** To the north-east of the SE Asian subcontinent and subparallel to the Paleogene Red River Fault, runs the Ailaoshan belt, as a part of the Yangtse block. Bound by the Song Ma and Ailaoshan sutures, the Song La marine furrow encompasses a substantial Paleozoic (4000 m) and an approximately 1000 m Triassic cover that consists of carbonates ending in plant and coal bearing clastics (Martini et al., 1998).

The **Indochina Block** consists of the *Loei-Jiangchen* and *Phetchabun* units. While Loei-Jiangchen has a Paleozoic cover, with a Devonian – Carboniferous history of rifting and compressional deformation, a gap spans the interval between Permian and Late Triassic. The Phetchabun fold and thrust belt (Helmcke, 1984, 1986) includes remnants of a Permian oceanic seaway that closed in the Late Middle or earliest Late Permian. Bound by the Nan – Uttaradit suture to the west and by the Loei suture to the east, Helmcke's Phetchabun belt corresponding to part of the Nakhon-Thai block of Charusiri et al. (2002). The Mesozoic cover is continental and consists of the Khorat Group starting with the Carnian –Norian Huai Hin Lat and Nam Pong formations (Helmcke, 1983).

The **Nan-Uttaradit suture** has been considered by many to represent the main divide between the Shan-Thai and Indochina terranes (Carey et al., 1995). The Paleozoic Lancang - Uttaradit ocean, characterized by radiolarian cherts, serpentinites and siliciclastic turbidites, was closed in late

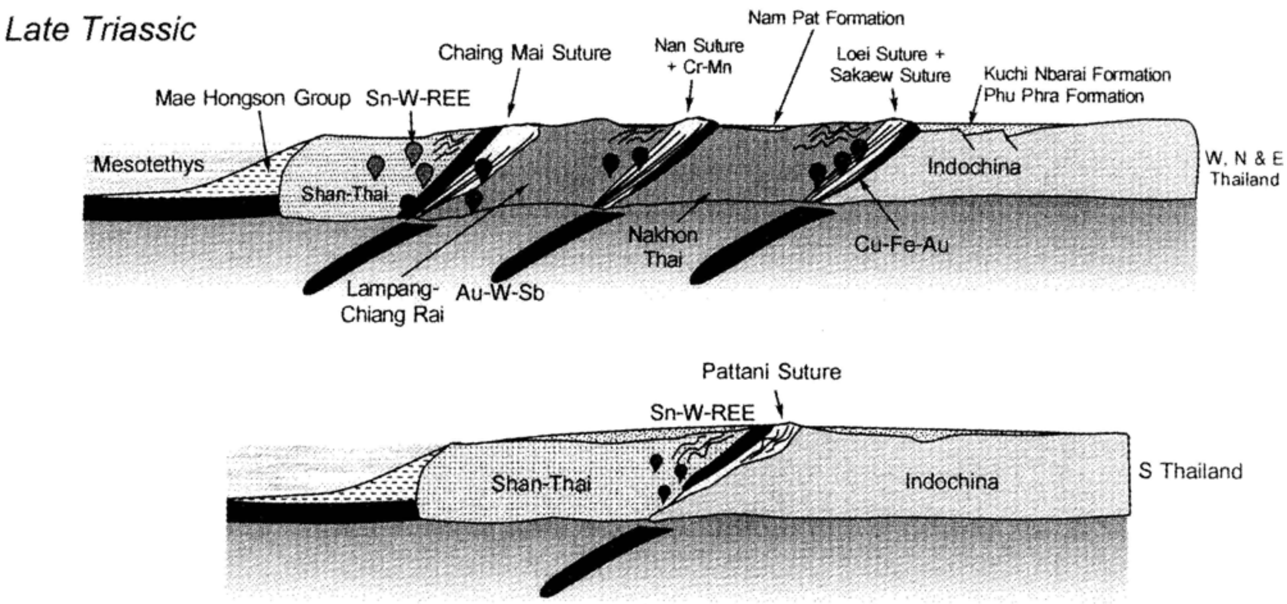

Fig. 1. Middle - Upper Triassic Plate Tectonic reconstructions of Thailand (Charusiri et al., 2002).

Table 1. Paleozoic - Triassic facies and tectono-environments characterize each of the Shan-Thai Zones. The proposed scheme is based on Chonglakmani and Grant- Mackie (1993), Sashida and Igo (1999), Meesook (2002) and Chonglakmani (2002).

ZONE	Northern Thailand	Chanthaburi	Peninsular Thailand -Malaysia
Sukhothai-Zone	Paleozoic-Triassic clastics, carbonates and turbidites associated with rhyolitic and andesitic volcanism reaching 5000m in the Lampang- Phrae basins of NE Thailand **(L);**		East Malaysia: Triassic Semantan Formation
Chiang Rai suture	Permian-Triassic radiolarian cherts	cryptic	Bentong- Raub Suture
Inthanon Zone	Paleozoic and Triassic		Triassic of Songhkla **(So)**
Mae Sariang Zone	Permian and Triassic oceanic bedded cherts and orogenic deep marine shale, extending from Mae Hong Son – Mae Sariang **(Ms)** - Mae Sot – Umphang **(TAK)** – Kantchanaburi **(Ka)**	Permian-Triassic oceanic/orogenic deposits	Triassic oceanic/orogenic Phatthalung **(P)**, Chaiburi **(C)**, Semanggol **(Sg)**
	Gondwana-Tethys Divide		
“Western” Zone	**Tengchon-Tenasserim Zone** Permian tillites Triassic epicontinental platform, devoid of volcanics		**Phuket Zone** Early Permian tillites Triassic Kodiang limestone **(K)**

Middle Permian (Helmcke, 1986; Chonglakmani and Helmcke, 1989; Carey et al., 1995). As the Nan-Uttaradit suture seems to contain the remnants of the Paleozoic early Indosinian orogenic event, Middle Triassic radiolarian cherts in the region (Feng et al., 2002), were possibly thrusted in from the west (Chonglakmani, 2002). This view is now also supported by thrusting along the Nan Suture (Charusiri et al., 2002). Fontaine et al. (2002), following Ueno (1999), do not regard the Nan-Uttaradit suture as the main closure of paleo-Tethys.

The **Shan-Thai Block** extends west of the Nan-Uttaradit suture. Its eastern part comprises the internal and central zones of “Thai”. Its western part, across the “Gondwana –Tethys Divide” (Ueno, 1999), encompasses the external “Western” zones of “Shan”, bound by the Sagaing Fault. The elements of Shan-Thai consist of four main elements or zones (Fig. 2), three of them being characterized by distinctive Triassic stratigraphic sequences in the Malay Peninsula (Fig. 3).

(1) The ***Sukhothai zone*** (Bunopas, 1981; Barr and McDonald, 1991; sensu Ueno, 1999; Chonglakmani, 2002) lies adjacent to the Nan-Uttaradit suture. It consists of a Paleozoic substratum of phylites. Where less affected by Permian metamorphism, these phylites are separated by a Middle Permian regional angular unconformity. Acid magmatism is either post-orogenic or related to a Permian -Triassic volcanic arc. Extensional semi-grabens or intra-continental rifts that formed since Late Permian times are filled with the Triassic Lampang Group that includes turbidites, as the Hong-Hoi Formation. Representing a fore-arc basin for Bunopas et al. (2002), Chonglakmani and Helmcke (1989) compared the turbidites and deepwater fauna of the Lampang Group to marine intra-montane molasses, similar to the marine intracratonic Dien Bien Phu basin in Vietnam (Staritskyi et al., 1973). The Semantan Formation of the Central Belt in Peninsular Malaysia, situated east of the Bentong-Raub suture (Metcalfe, 1990b), has been seen as correlative with the Lampang Group (Chonglakmani, 2002). The Sukhotai zone is bound to the west by the ***Chiang Rai zone.*** This dislocated zonal border is characterized by a deep marine and oceanic furrow that yields Late Paleozoic - Triassic radiolarian cherts (Feng et al., 2001; Sashida et al., 1995). Chonglakmani (2002) connects the Chiang Rai zone southwards into the Chanthaburi zone and further south with the Bentong-Raub suture.

(2) The ***Inthanon Zone*** (Barr and McDonald, 1991; sensu Ueno, 1999) in N. Thailand, corresponds to the Doi-Inthanon – Lincang unit of Chonglakmani et al. (2001), also called Chiang-Mae terrane (Chonglakmani, 2002) and most recently Inthanon Terrane (Feng et al., 2005). It is bound, west of the Chiang Mai basin, by high grade metamorphic core complexes (McDonald et al., 1993). Granite intrusions are mostly Triassic. The oldest sediments are Cambrian or Ordovician. Carboniferous and Permian shallow marine carbonate platforms are tropical or subtropical (Toriyama, 1944, 1984; Konishi, 1953; Fontaine et al., 1993). Late Paleozoic – Middle Triassic siliciclasts and radiolarian ribbon cherts occur locally (Luning, 1994) and Middle Triassic radiolaria ar found at Lamphun (Feng et al., 2002). Jurassic red beds fill local graben structures (Luning et al., 1995). Toefke et al. (1993) interpreted this zone as the disrupted passive Late Permian continental margin of paleo-Tethys with immature clastic deposition during the Triassic. Helmcke (1984) suggested a Late Devonian or Early Carboniferous detachment from Gondwana and its close vicinity to paleo-Eurasia for most of the upper Paleozoic. This assertion is based on *Walchia piniformis* as well as Middle Carboniferous – Early Permian fusulinids in Western and Eastern Thailand alike (Toriyama et al., 1978; Ingavat et al., 1980). The associated

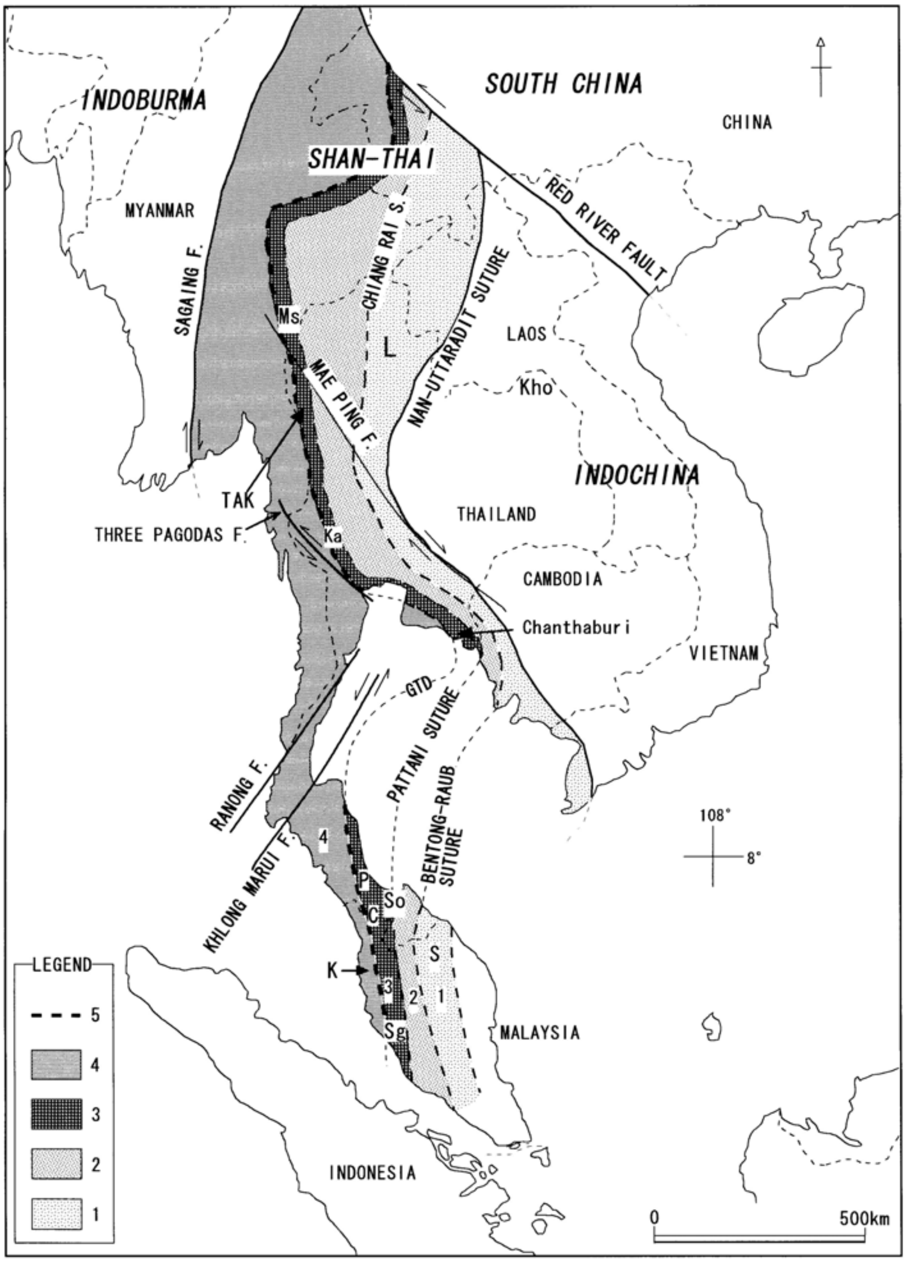

Fig. 2. Tectonostratigraphic terranes of Southeast Asia (modified after Hada et al., 1997; Ueno, 1999; Bunopas et al., 2002; Chonglakmani et al., 2001; Gondwana-Tethys Divide after Myo Min et al., 2001). Triassic basins are after Chonglakmani and Grant-Mackie (1993) and Meesook et al. (2002). Legend: 1. Sukhothai Zone; 2. Inthanon-Zone; 3. Mae-Sariang Zone; 4. "Western" zones (Tengchon -Tenasserim and Phuket); 5. Gondwana-Tethys Divide (GTD). Triassic basins and formations: C: Chaiburi Formation; K: Kodiang Limestone; Ka: Kanchanaburi; Kho: Khorat Group; L: Lampang–Phrae basin; Ms: Mae Sariang; P: Phatthalung basin; S: Semantan Formation; TAK: Mae Sot - Umphang area; Sg: Semanggol Formation; So: Songhkla basin.

Changnin - Menglian Belt to the north has Devonian deep-water sediments and Carboniferous -Permian shallow warm platform carbonates of Tethyan faunal affinity (Feng et al., 2005).

(3) The **Mae Sariang Zone** runs along the NS-trending Tertiary strike-slip valley of Mae Nam Yuam, northwest of Mae Sariang, where Permian and Triassic ribbon cherts and true pelagic limestones occur that Hahn and Siebenhuner (1982) and Fontaine and Suteethorn (1988) attribute to the Shan-Thai Terrane. The pelagic sequence is followed by syn-orogenic siliciclastic turbidites (Toefke et al., 1993), which are located near the western border of Lower Permian warm-water limestones (Helmcke et al., 1993). A conglomerate with radiolarite pebbles yielding radiolarians determines the age of the Mae Sariang orogeny. Their Guadalupian (Late Kazanian to Early Tatarian) and Middle Triassic (Anisian –Ladinian) age (Caridroit et al., 1993), confers the host-conglomerate a Late Triassic or younger age, probably Jurassic. Kamata et al. (2002) put in evidence the palaeogeographic significance of the Spathian to Carnian radiolarians in the closure of paleo-Tethys. Fontaine and Suteethorn (1988) first mentioned pelagic limestone along the highway Tak - Mae Sot (km 49.750), indicating the southern continuation of the Mae Sariang terrane boundary (Helmcke, 1994). Chonglakmani et al. (1991) extends the Mae Sariang Basin into the Kanchanaburi Basin where siliciclasts are exposed along Khwae

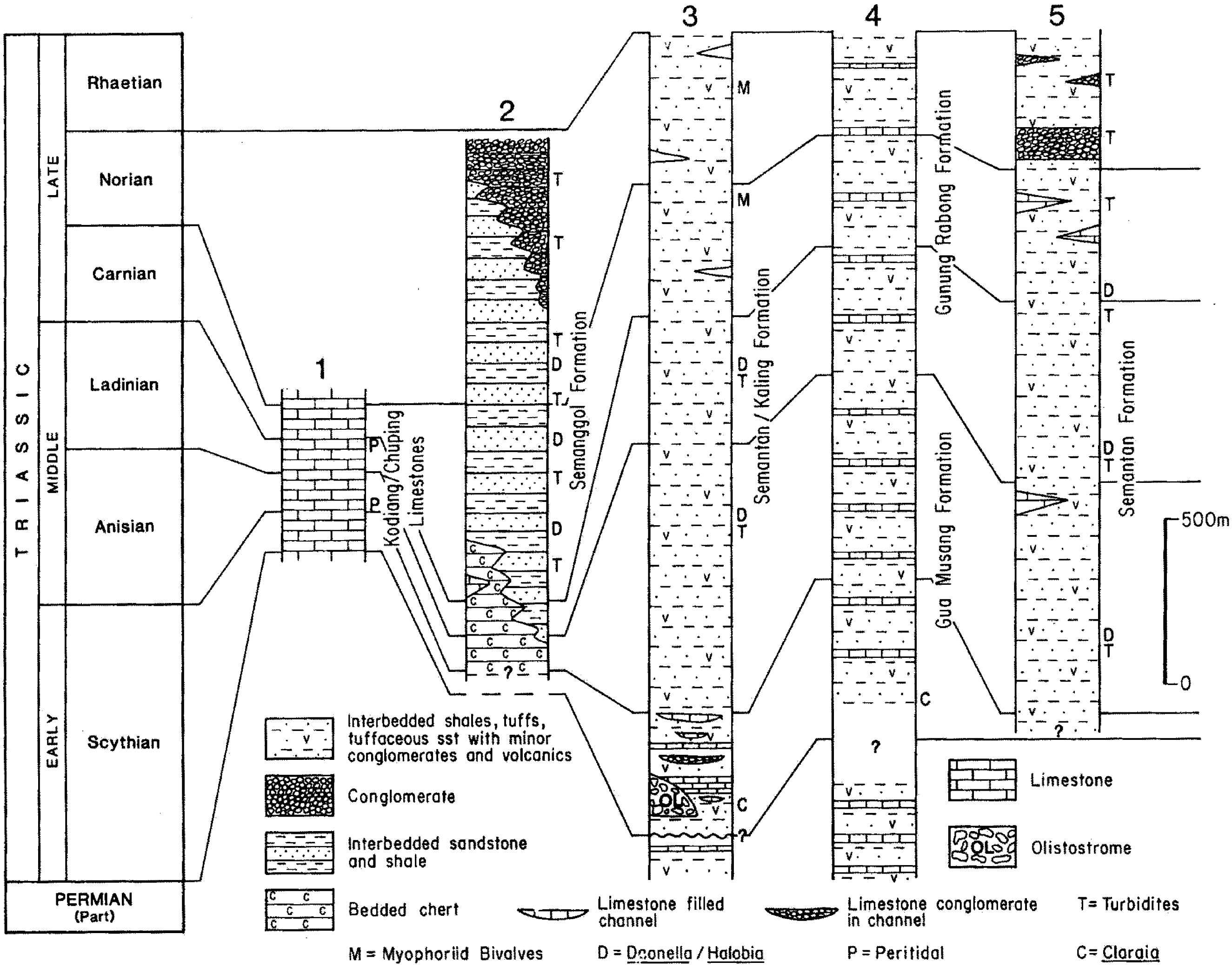

Fig. 3. Triassic stratigraphy of the Shan-Thai Block of the Malay Peninsula: (Metcalfe, 1990b): (1) "Western-zone"; (2) Mae-Sariang Zone; (3, 4, 5) Sukhotai-Zone.

Yai, at Ban Chong Khap (Bunopas, 1981). Sediments yielding Permian and Triassic radiolarian faunas occur in the Mae Hon Son area of northwestern Thailand (Saesaengseerung et al., 2005).

The continuity within the Mae-Sariang – Kanchanaburi Basin is supported by the sequence of shale, sandstone and conglomerate, intercalated with chert and limestone, yielding *Daonella* and *Halobia*. Such sediments are exposed in the Tak - Mae Sot and Umphang areas. At km 34 of the Tak-Mae-Sot road, mudstone with *Halobia*, wood fragments and poorly preserved radiolarians occur, topped by chert beds, containing fine vitritic-tuff and yielding radiolarians of Middle to Late Triassic age (Ishida et al., 2004, 2006). There it is covered by a breccia, composed of poorly sorted angular-subangular clasts of limestone and chert with red sandstone and siltstone. Among the fragments of limestone and cherty tuff, limestone fragments contain Early and Late Triassic conodonts, whereas the cherty tuff fragments contain Middle and Late Triassic radiolarians. The Chantaburi chert-clastic sequence (Hada et al., 1997) contains Late Permian - Late Triassic radiolarians that can be associated with those of the Mae Sariang zone. In Peninsular Thailand, Triassic Na Thawi and Chaiburi mud- and limestone in the Phatthalung area have been singled out (Ampornmaha, 1995; Sashida and Igo, 1999). Other sediments, similar to those of Mae Sariang, are found in the Semanggol Formation (Sashida et al., 1995), in Kedah, Malaysia (Fig. 3).

In the southern Shan States, Myanmar, along the Pan Laung Fault, Garson et al. (1976) described the Triassic turbidites of the Maubin Formation, sealed by Rhaetian coal seams and Middle Jurassic red beds.

(4) The external "**Western**" **Zone** encompasses Ueno's (1999) "Sibumasu Block", the Tengchong-Tenasserim and Phuket zones of the "Western Units" of Chonglakmani et al. (2001) as well as the Shan block of Feng et al. (2005). It comprises Gondwana derived Cimmerian terranes that docked

during a Triassic orogenic event. Crystalline pebbles of glacial-marine origin, as young as Stephano-Asselian, covered by late Early Permian limestone with impoverished faunas. Its Triassic cover is represented by the Kodiang-Limestone (Fig. 3).

2.3.1. The Sutures

As it appears from the work of many researchers, the Shan-Thai and Indochina terranes consisted of several structural subunits each. The Carboniferous, Permian and Triassic radiolarian ribbon chert and pelagic limestone, as well as the Late Permian and Triassic platform deposits, bear witness for the history of several marine furrows, primarily along or within the suture zones that frame Shan-Thai and Indochina terrane-fragments.

Among these, the Nan-Uttaradit-Raub-Bentong suture has been long regarded as the Late Triassic-Earliest Jurassic welding of the blocks that compose Thailand (Nie et al, 1993; Metcalfe 1998; Shi and Archbold, 1998). Since Hada et al., (1997) the tracing of this line makes a bend that includes the Sra Kaeo – Chantaburi zone (Fig. 4).

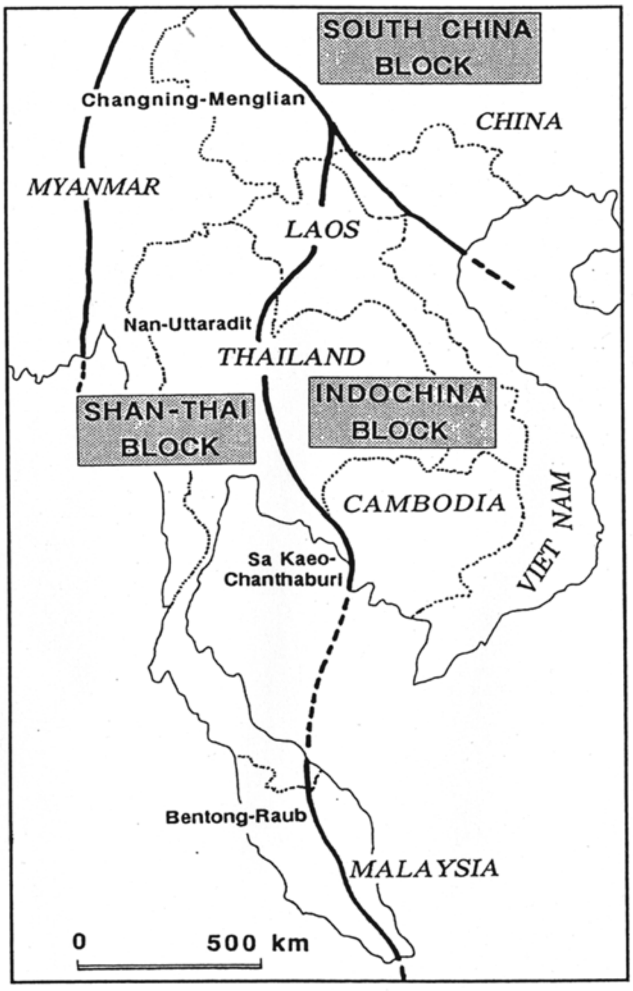

Fig. 4. Tectonographic terranes of Southeast Asia (Hada et al., 1997).

The connection by Chonglakmani (2002) of the Sra Kaeo-Chanthaburi zone with the dislocated or 'cryptic' Chiang Rai zonal border (Ueno, 1999), which runs between Sukhotai and Inthanon, opens the way to a different interpretation. Based on the understanding that the Nan-Uttaradit suture most probably represents an Early Indosinian Late Middle Permian event (Chonglakmani and Helmcke, 1989), the Chiang Rai zonal border, or Chang Mai Geosuture (Feng et al., 2005) and the better documented Mae Sariang oceanic furrow indicate a Late Indosinian Late Triassic event (Fig. 2).

Since the region has been wrenched by sinistral strike slip faults (Mae Ping, Three Pagodas) during the Cenozoic, the original spatial relations between the area of Kanchanaburi and that of Chantaburi may have changed substantially.

Given the structural narrowing of the Inthanon zone towards the south, the Mae Sariang and Chiang Rai zones may nearly merge within the Chanthaburi zone, where the several Shan-Thai elements are compressed into a single sutural bundle (Fig. 2). The abundant petrological and micropaleontological evidences brought forward by Caridroit et al. (1993), Hada et al. (1997), Ishida et al.(2004) and Saesaengseerung et al. (2005) corroborate the similarity of the Mae Hon(g) Son – Mae Sariang – Mae Sot – Kanchanaburi and Chantaburi zones. South of Chantaburi, the Shan-Thai elements can be identified again. East of the Bentong-Raub suture, East Malaya, characterized by the Semantan Formation, a Triassic Lampang Facies equivalent, is correlative with the Sukhothai zone (Chonglakmani, 2002). Yet, in Peninsular Thailand, the space between Bentong-Raub and Gondwana-Tethys Divide is occupied by Triassic deposits of the Songkhla basin, Phatthalung and the Semangol turbidites that suggest equivalence with the Inthanon - Mae Sariang zones.

2.4. The Gondwana-Tethys Divide

The line that signals approximately the margin between Early Permian subtropical paleo-Eurasian and glacial marine Gondwanid elements (Ingavat-Helmcke and Helmcke, 1994; Ueno, 1999; Chonglakmani et al., 2001; Myo Min et al., 2001; Feng et al., 2005) runs west of the Mae Sariang basinal type sediments that separate the Inthanon zone from the Tengchong - Mergui-Tenasserim zones. Helmcke et al. (1993) speculated a huge ocean, located westward of the shallow Paleozoic platform in northern Thailand. For Toefke et al. (1993), the region of Mae Sariang hosts the boundary zone to the Gondwana derived terranes of Southeast Asia. In other words, the region east of Mae Sariang can be regarded as the paleo-Eurasian margin of paleo-Tethys while the region west of Mae Sariang has a Gondwanian origin (Caridroit et al., 1993).

This *Gondwana-Tethys Divide* (GTD) (Ueno, 1999; Wang et al., 1997) follows the Nujiang Fault/Suture in Yunnan and the Mae Yuam Fault in northern Thailand. Besides paleontological and tectonic aspects, abundant chromium spinels in the "Mae Sariang Group" of the Mae Hong Son – Mae Sariang area, possibly of intraplate origin may indicate a suture or other tectonic boundary, suggesting that the GTD is located along the Mae Yuam Fault zone (Hisada et al., 2003). In Peninsular Thailand and Malaysia, the GTD apparently corresponds to the border between the glacial pebble (Phuket) and carbonate (Rat Buri) facies.

2.5. Stages of evolution of Shan-Thai

The evolution of the Shan-Thai terrane took place in a succession of phases:

2.5.1. Paleozoic

The paleo-Tethys poly-island ocean (Liu et al., 1993) spread over several palaeo- latitudes, expressed in biogeographical criteria (Shi and Archbold, 1998). These include the cold- water Gondwana type facies, predominant in the more external "Shan" elements of Shan-Thai, while the transitional Sibumasu type and the paleotropical warm-water Cathaysian type occur in the intermediary and more internal "Thai" elements of Shan-Thai. A first phase of oceanic extension, approximately at 360 Ma created the Nan-Uttaradit rift basin, floored by oceanic crust (ophiolites). This basin closed at 265 Ma (Middle Permian) creating the intra-Permian unconformity. This end Middle Permian closure of the Nan-Uttaradit suture (Early Indochina orogeny) probably merged the most internal part of Shan-Thai to Indochina, making it a part of Laurasia (Helmcke, 1985; Chonglakmani et al., 2001).

2.5.2. Late Permian – Triassic

Several marine basins remained open, reopened or were newly developed. Their varied facies can be summarized after Chonglakmani (2002) and Meesook et al. (2002) into three main types: **(a)** epicontinental platform, devoid of volcanics, found in the Semanggol and Chaiburi formations in Peninsular southern Thailand; **(b)** the disputed fore-arc (Bunopas et al., 2002) versus intramontane clastic, carbonatic and turbiditic type (Chonglakmani and Helmcke, 1989), associated with rhyolitic and andesitic volcanism, reaching a thickness of 5000m in the Lampang-Phrae basins of NE Thailand; **(c)** deep marine shale and oceanic bedded cherts.

The end Triassic- Early Jurassic Late Indochina Orogeny closed all these paleo-Tethys basins, amalgamating all Shan-Thai and Indochina elements into a new SE Asian basement. The Late Permian - Triassic basins primarily occur along or within suture zones that weld Shan-Thai and Indochina elements. The main event took place within the string of oceanic type furrows that runs from NW into SE Thailand, representing a single zone from Mae Hon(g) Son – Mae Sariang – Kanchaburi to Chantaburi, as corroborated by petrological and micropaleontological evidence (Caridroit et al., 1993; Hada et al., 1997; Ishida et al., 2004; Saesaengseerung et al., 2005; Ishida et al., 2006).

2.5.3. Jurassic-Cretaceous-Early Paleogene

The end Triassic tectonic phase not only completed the assemblage of the allochthonous elements forming the Shan-Thai, it brought the paleo-Tethys to its end. The newly formed South East Asian basement, being the product of the welding of several blocks together became part of Eurasia. While accretionary complexes are suspected to have formed only along the sutures, the block-like pattern of the units lying in between, suggests fairly undisturbed platform fragments, the bulk of which had docked before being tectonically deformed by the End-Triassic – Early Jurassic Late Indosinian orogeny. The new basement has a marine Jurassic cover with faunas of strict autochthonous character (Kozai et al., 2006). The Early Jurassic Mogok orogeny in Myanmar (Mitchell et al., 2002) is probably a Late Indosinian phase, possibly related to Early Jurassic stitching plutons (Hada et al., 1997). The Mid-Cretaceous Shan orogeny (Mitchell et al., 2002) belongs into the Mesotectonic Stage (Charusiri et al., 2002), further contributing to compression in Thailand.

2.5.4. Cenozoic

The Oligo-Miocene Alpine-Himalayan Indo-Eurasian collision inflicted severe chaos on the rather structurally quiescent Jurassic-Cretaceous SE Asian subcontinent. The collision resulted in the clockwise rotation of SW Asia, squeezing the tectonic units of western Yunnan into a narrow structural bottle neck and eventually resulting into extrusion tectonics (Leloup et al., 2001). The extrusion of Shan-Thai and Indochina took place along the Sagiang and Red River transforms (Lacassin et al., 1997). For Morley (2004), the left lateral motion on the NW–SE-trending strike-slip fault zones (Mae Ping and Three Pagodas) is part of a diffuse, branching network of faults with important north–south as well as NW–SE trends that may represent a substantial Late Cretaceous–Palaeogene transpressional belt, Himalayan escape tectonics representing later increments of deformation with both Oligocene sinistral and late Oligocene–Recent dextral reactivation. The Cenozoic tearing apart along the Wang Chao (Mae Ping) fault Zone, initially a sinistral transform colliding with the dextral Sagiang fault, and the Three Pagodas Fault Zone, among others, have wrenched Thailand to pieces.The subsequent change in sense of strike slip movement of some of these faults (e.g., Mae Ping Fault) further dislocated the Shan-Thai puzzle (Fig. 2).

3. CONCLUSIONS

The Shan-Thai Terrane, as a remnant of paleo-Tethys in South East Asia, consists of three main Late Paleozoic facial developments: the warm water Cathaysian facies, alongside

Indochina, the central intermediary "Sibumasu" facies and the Gondwana facies. The first two are found in the "Thai" elements of the Sukhotai-Lampang Zone, Inthanon-Chiang Mai Zone and Mae-Sariang Zone. The third consists of the external "Western" Zone of Tengchon-Tenasserim- Phuket or "Shan" elements, characterized by Permian glacial sediments.

The Nan-Uttaradit suture is the Early Late Permian Lower Indosinian scar between "Thai" and Indochina, having no major role in the final welding of Shan -Thai.

The final welding of SE Asia took place during the Late Indosinian orogeny, in Late Triassic - Earliest Jurassic times. A major scar, for which the Jurassic basal breccia bears witness, runs along a line of deep sea facies, known from Mae Hon - Mae Sariang -Tak – Kantchanaburi to Chantaburi. This orogenic axis is strongly offset by Cenozoic strike slip faults (Mae Ping, Three Pagodas, Ranong and Khlong Marui). In the traverse of Chantaburi most of Shan-Thai is reduced to a narrow bundle of several sutures, resembling the comparable Yunnan bottle neck. This is the result of extreme tectonic compression, as a consequence of Cenozoic Himalayan escape tectonics along the Sagiang and Red River transforms.

The links across eastern Thailand's Chanthaburi to southern Thailand and Malaysia are tentative. East of the Bentong-Raub suture in the Central Belt of Peninsular Malaysia, the development of the Semantan Formation, similar to the Lampang facies in Northern Thailand (Chonglakmani, 2002), suggests the extension of the Sukhotai Zone to Peninsular Thailand and the equivalence of the Bentong-Raub and Chiang Rai sutures.

The Mae Sariang Zone of Northern Thailand is deflected in the Chantaburi structural bundle. In southern Thailand, the Inthanon- Mae Sariang border line apparently corresponds to the Pattani suture of Charusiri et al. (2002). The southern Thailand Phatthalung facies, Chaiburi Formation and the NW Malaysian Semanggol Formation are equivalent to the facies of Mae Sariang. Across the GTD, the Kodiang limestone facies belong into the "Western" Zone.

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