International Conference on Stratigraphy and Tectonic Evolution of Southeast Asia and the South Pacific
ngkok, Thailand, 19-24 August 1997

Tectonic Evolution of Thailand : From Bunopas (1981)s to a new scenario

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EXTENDED ABSTRACT

Thailand, on the basis of Bunopas 1981)'s model, comprises two major tectonic erranes namely Shan-Thai and Indochina, malgamated during Late Triassic and onstituting the prime portion of mainland SE sia. Tectonostratigraphically, four main ectonic events occurred in Thailand - rcheotectonics, Paleotectonic, Mesotectonic, nd Neuvotectonic episodes.

In the **Archeotectonics** period, Shan-Thai and Indochina microcontinents acted as the eparated cratonic fragments of Gondwana and an-Cathaysia super continents and their asements lithologies are marked by the recambrian high-grade metamorphosed core omplexes (Fig. 1.A).

The Paleotectonic event is believed erein to commence with the major marine ransgressive over both Shan-Thai and Indochina microcontinents, causing the edimentation of Cambrian cold, shallow-water helf, siliciclastic facies, Ordovician open marine carbonate platforms, and Silurian and Devonian deeper (volcani-) clastic materials. These sequence of both terranes, therefore, acted as accretionary wedges in the passive continental margin (Fig. 1.B).

The important of the Paleotectonic event was controlled during Devonian by poly-arc Benioff subduction and extension tectonics. This gives rise to newly proposed two 'small' tectonic blocks developed between Shan-Thai and Indochina, namely Nakhon-Thai ocean floor (Paleotethys) to the east and Lampang-Chiang Rai volcanic arc to the west.

Rapid drifting of Shan-Thai from its present megalandmass to lower latitude, was marked by the Permo-Carboniferous rifted sediments. This may have caused weak metamorphism of Lower to Middle Paleozoic sediments. This drifting, in turn, changed the depositional environment from cold to more warm (or even hot) affinities, as evidenced by the appearance of gypsum, coal, and prolific marine lives. Subsequently, violent subduction temporarily ceased and carbonate-shelf to - platform facies were developed during Permian. However, during Permian, Indochina lied close to the paleo-equator. By the end of Late Paleozoic, calc-alkaline poly-magmatic arcs with weak porphyry- and Kuroko-style mineralization, were generated as a result of west-dipping subduction zones beneath Lampang-Chiang Rai and Nakhon-Thai blocks. Paleomagnetically, our study confirms that Shan-Thai became very close to Indochina at low latitude in northern hemisphere during Early to Middle Mesozoic (Fig. 2).

Marine Triassic sedimentation took place in western Shan-Thai as passive continental margin facies, Lampang-Chiang Rai arc as fore-arc and back-arc basinal facies, and Nakhon-Thai as open-marine flysch-type facies. By Middle to Late Triassic, all associated

terranes collided with each other suites (Nakhon-Thai vs. Indochina) (see Figs. 2 and 1.C). Contemporaneously, voluminous S-type granitoids (with Sn-W-REE) occurred widespread as a result of partial melting of the Shan-Thai sialic crust, becoming the Central Granite Belt. The existence of the Triassic I-type granitoids, with porphyry Cu-Au and Pb-Zn-Fe skarn-type, were governed by the on-going and intense west dipping subduction of oceanic lithosphere beneath Nakhon-Thai thin crust and delineated the Western Granitoid Belt. All these magmatic activities are inferred to indicate the cessation of the Paleotectonic event, and the advent of **Mesotectonic** Period (Fig. 1.C).

Due to subsequent tectonic convergence, Shan-Thai and Indochina as well as their allied blocks underwent tremendous compressive stress, and possibly all terranes reach to high latitude of the northern hemisphere and stopped moving further. Upthrusting of eastern Lampang-Chiang Rai onto Nakhon-Thai, and eastern Nakhon-Thai onto western Indochina terranes, may have caused Jurassic Cretaceous, continental, mollasse-type redbeds over much of Nakhon-Thai and west of Indochina, respectively. Earlier than that limited extent of Mesozoic redbeds occurred in the Lampang-Chiang Rai possibly due to intensive denudation of the Chiangmai ophiolite obduction. In southern and eastern Thailand, with different tectonic styles and Late Paleozoic sequences, Shan-Thai collided with Indochina without significant continental redbeds. Termination of major marine transgression - except to the west of Shan-Thai and the significant emergence of landmass with continental sedimentation and abundant dinosaurs characterize the Mesotectonic event. By mid Cretaceous, east - dipping subduction of oceanic lithosphere beneath western Shan-Thai triggered I-type granitoids with weak Au-Cu-Fe, and in the end of Cretaceous Western Burma block collided with Shan-Thai terminated the Mesotethys, and caused the S-type granitoids with Sn-REE in the west of Shan-Thai. These Shan-Thai granitoid suites denoted the Western Granite Belt. Contemporaneously, as a result of plate interaction, dramatic and prolong climate and ecology changed, dinosaurs became mass-extinct, and the Subkha-type rocksalt and evaporites developed subsequently in both Khorat and Nakhon-Thai basins.

The continental collision of India with Asia during Early Tertiary advocated the evolution of **Neuvotectonic** (Fig. 1.D). The regional uplift of Khorat and affiliated basins the generation of the Phu Phan Anticline and the Nakhon-Thai Synclinorium may have formed due to such collision. As extrusion tectonics developed in Asia, the compression occurred in India and Thailand plus the whole SE Asia were subject to extension tectonics. This remarkable modification in tectonic style during mid-Tertiary may have caused the opening of the Gulf of Thailand, the rift-generated basins, and the deep-seated N-trending fractures. The culmination of the Neuvotectonics is likely marked by the latest occurrence of mantle-derived, gem-bearing basalts and the NE Thailand tektites during Middle Pleistocene. The latter corresponded fairly well with the late geomagnetic reversal and may have linked to the late regional uplift, causing major Sn-, Au-, and gem-bearing secondary deposits, emergent western the Gulf shorelines, submergent Andaman shorelines, and successive development of alluvial terraces and fans in central Thailand. Neuvotectonics still currently persists as characterized by hot springs and historical and present-day earthquakes, creating "Neotectonics" - senso stricto. However, more information on paleomagnetism and geochronology are inevitably required in order to unravel the more precise tectonic evolution of the country.

The overall tectonic evolution of Thailand is summarized in Table 1 and paleogeographic reconstruction is illustrated in Figs 1 and 2.

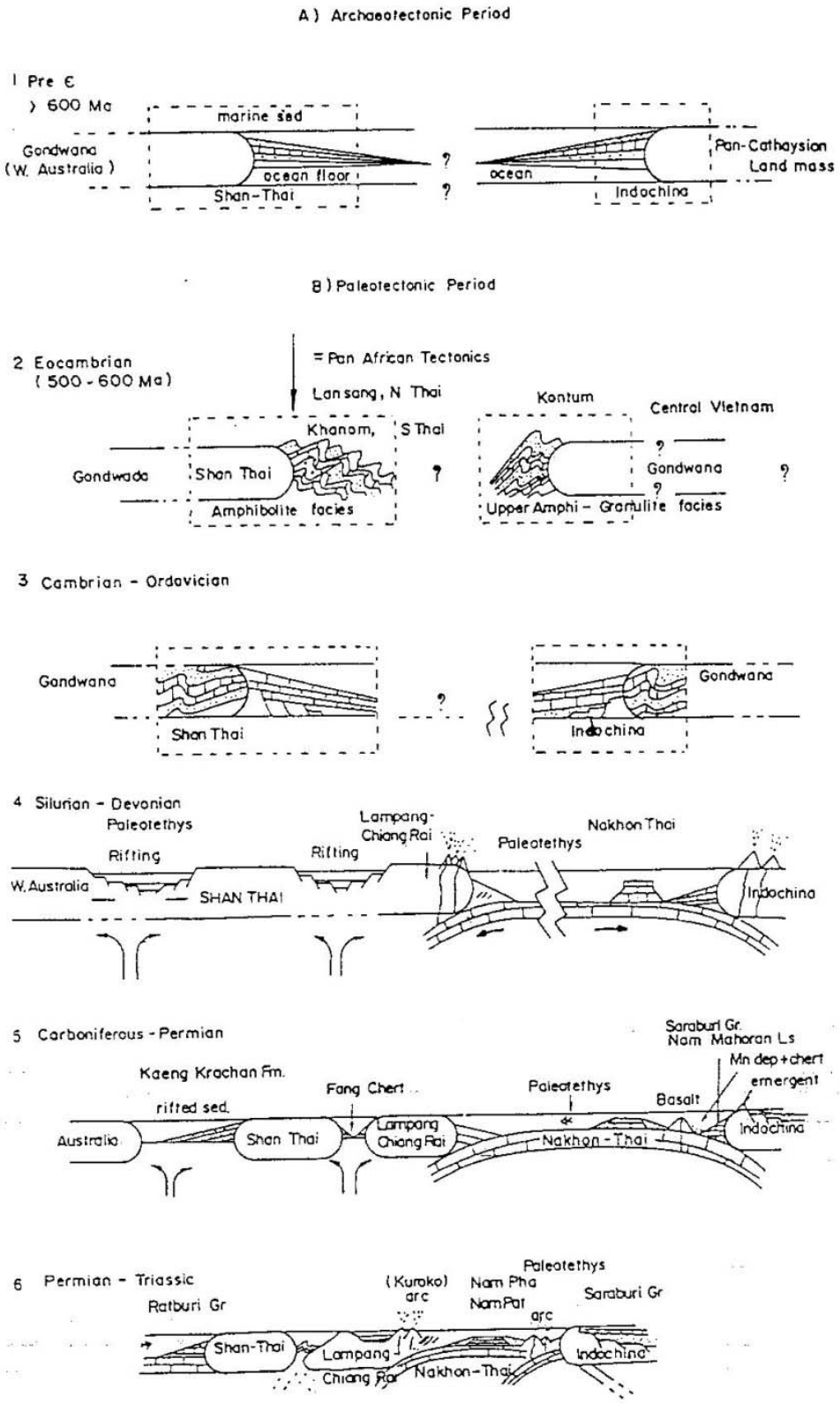
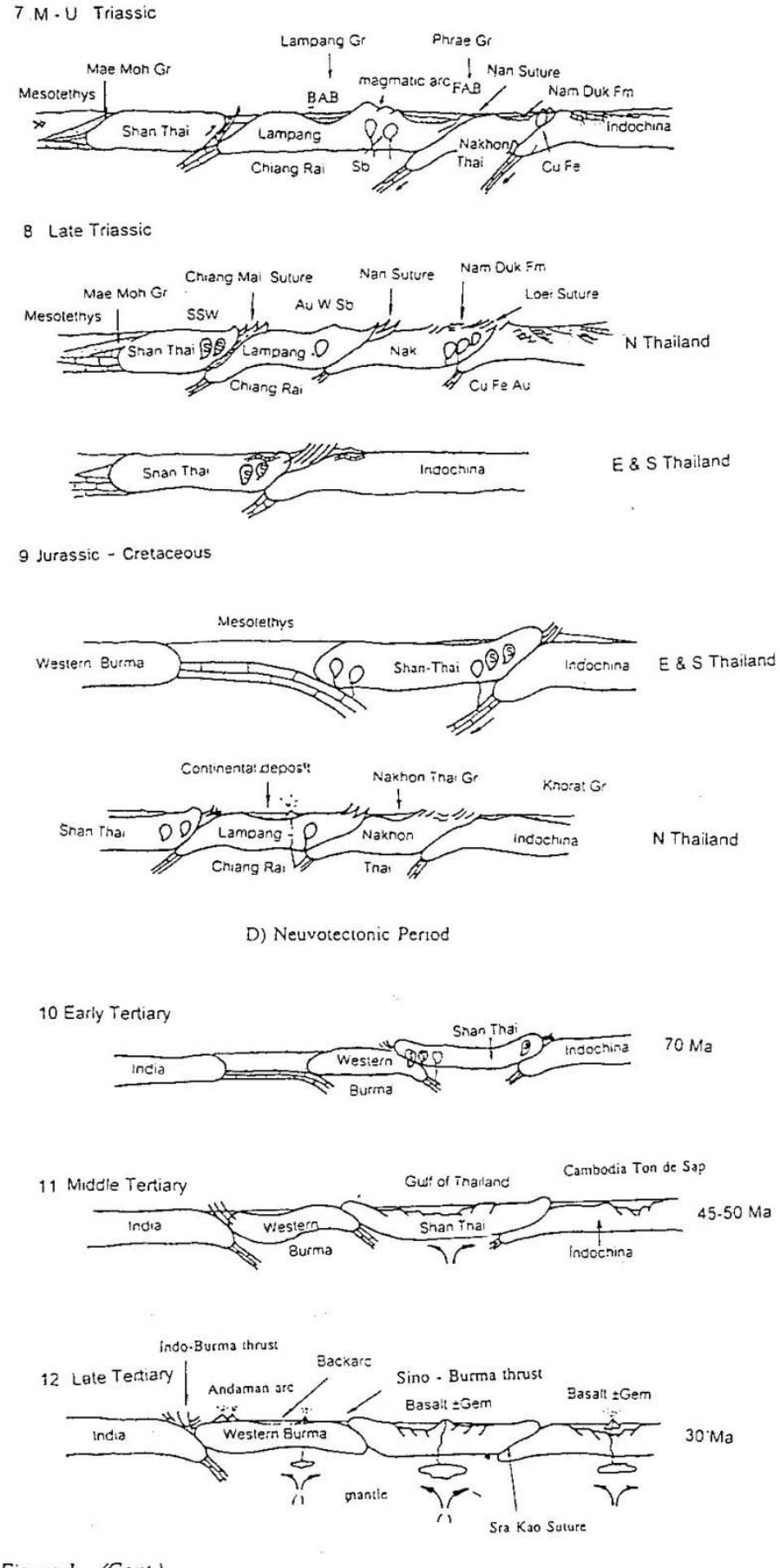


Figure 1 *Plate tectonic reconstruction of the evolution of Shan-Thai, Indochina and their allied microblocks (Nakhon-Thai and Lampang-Chiang Rai) during*

A) Archaeotectonic *B) Paleotectonic Period*

C) Mesotectonic *D) Neuvotectonic*

C) Mesotectonic Period



D) Neuvotectonic Period

Figure 1 (Cont.)

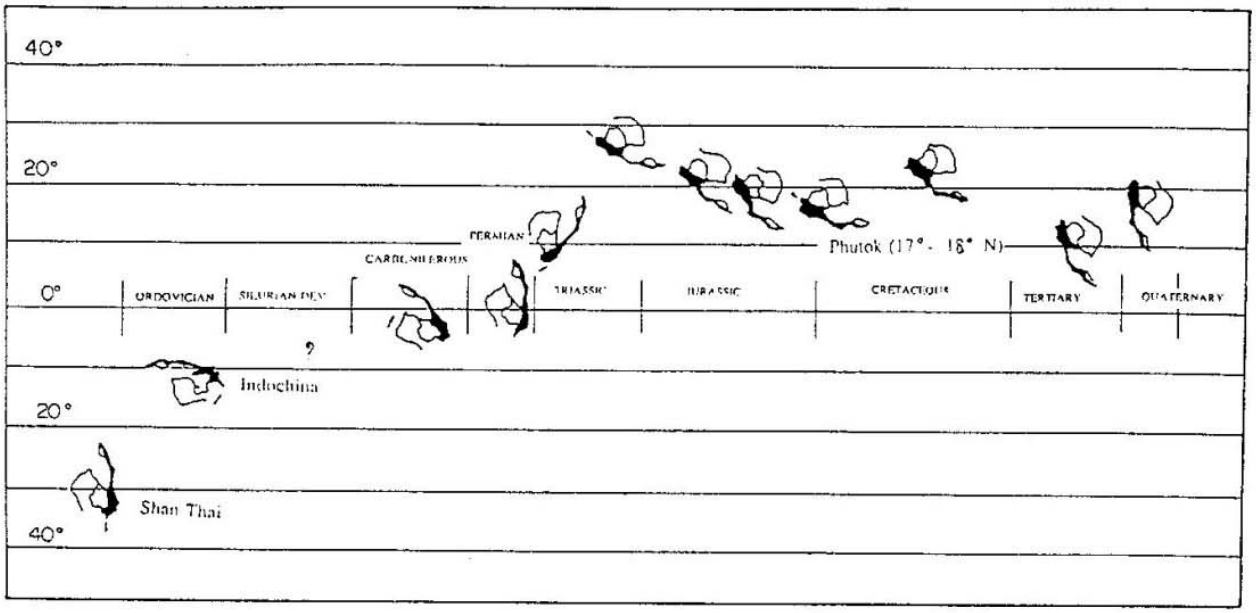


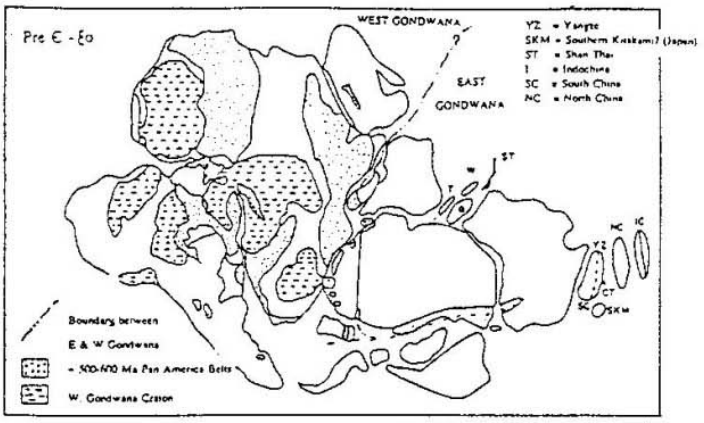
Figure 2 Approximate positions and rotation of Shan-Thai and Indochina from early Ordovician to Quaternary. Configurations of Shan-Thai (Block) and Indochina (unshaded) or comparison to present day, where both got into the same picture in Late Triassic.

Table 1 Summary of tectonic events of Thailand with emphasis on Shan-Thai and Indochina plates.

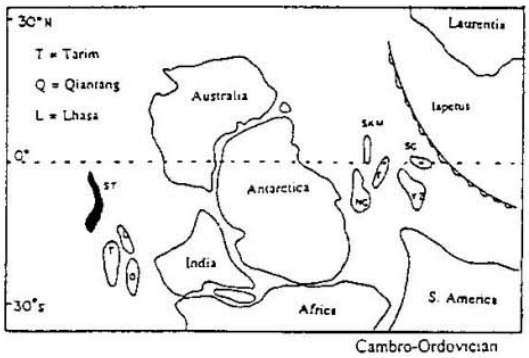
Era	Period	Episode	Plates kinematic	Activity	Style	Paleoenvironment	Sedimentation & Major lithofacies	Magmatism & Mineralization	Major Structure	Note
CENOZOIC	Quaternary: Holocene	Neotectonics; Sliver / Rafting	negligible movement of all plates	Neotectonics, rifting cont.	Earthquake	fluvial, beach, residual	ss, st, cl	none	Andaman submergent, Gulf coast emergent, earthquake morphology	Present land forms
	Pleistocene; Neogene: Pliocene, Miocene		plates rearranged close to present position	rifting continue		Lacustrine & fluvio-lacustrine in N., littoral to shallow marine (sublittoral) in Gulf&S. Thailand	st. dominates +/- ss	clay+diatom. & gem, secondary Au., Sn.dep. basalt(+/-gems.)	strike-slip, pull apart, N-trend.- basin and deep frac., half grabens, great unconf. in basins	Tektite impact (0.7 Ma); syn-sedimentary faulting
	Paleogene: Oligocene, Eocene	Extrusion	10° clockwise rotation India w. SE Asia	extensive rifting, extension fault, horst & graben		fluviolacustrine+/-supralittoral in Gulf of Thailand	ss. dominated +/- coal +/- st	granite (I&S types) +/- Cu, Fe, Sn, Au, Sb; +/- Sn-W-REE	opening of the Gulf, Chao Andaman, uplift inversion folding Phu Phan Uplift, Mae Hong Son&Sanamg F.	extensive denudation of 300 m thick of Phra Wihan in Phu Phan Range
	Paleocene		stress accumulated in all plates	Development of Neotethys	Himalaya II	dry to arid in Indochina hypersaline, land-locked lake	playa+/-alluvial plan (Mahasarakham)	Na, K, gypsum deposits, dickite	tilting & regional uplift reactivation of all major faults	possibly entire closure of Mesotethys
MESOZOIC	Cretaceous	Mesotectonics; Amalgamation	W. Burma to Shan-Thai block	closure of Mesotethys	Himalaya I	fluvial+/-marine sand flat, playa	purple, fine mica ark.+/-cl. pebble (Khok Kraut)	Uranium min. in Khorat Plateau	[illegible]	Paleocurrent NE to SW
			progressive clockwise rotation of all plates (Shan Thai, LC and NT & Indochina)	major westwards underthrusting of Shan Thai by Indochina in E and S Thailand, westwards underthrust of Shan Thai by LC, LC by NT, & NT by Indochina	Indochina II	low sinuosity, braided stream	pale ss., med.-co congl (Phu Phan)+Eolian (Phu Tok)			Paleocurrent NE to SW
						extensive flood-plain+meanders+/-crevasse spray	red clay&silt +/-caliche&carbonate nod (Sao Khoa)			Paleocurrent E to W
	Jurassic					semidistal braided.	grey ss. +/-var. coloured st. (Phra Wihan)	prominent volcanism (in LC block) +/- evaporite		Paleocurrent E to W
			all plates collided and amalgamated			shallow braided+/-meanders+/-playa	red ss.+/-cong (Phu Kradung)+pale ss (Waritchaphum)		NW Three Pagoda &NE Ranong F.	[illegible]
						lagoonal to paralic sed. in half graben, W. Indochina	clastic + volc.clastic (Huai Hin Lat & Nam Phong)	S-type granite +/-Sn-W-REE	NW Mae Ping&NE Klong Marui F.	Advent of Mesotethys & Marine Mae Moei Gr. (w. Shan Thai)
	Triassic	Suturing	Shan Thai (+LC) moved & drift northwards and attached Indochina (+NT) at Low Lat. of N Hemisphere	Shan Thai - Indochina & all plates collision L. Triassic at 20-30°N, closure of Mesotethys	Indochina I; Duration; Intensity	shallow to deep marine all over, lagoonal sed. west of Indochina (Khorat Plateau)	west: lst +/-sh, ss; center: lst+/-ss, sh, tuff; east: sh+/-ss, cgl.,lst	S-type granite+/- Sn-W-REE; I-granite+/- Cu-Fe-Pb-Zn-Sb-Au	west dipping isoclinal fold, eastward thrust, half graben in W. Indochina	west: L-Mae Moei Gr.; center: Lampang, Phrae & Pong Nam Ron Gr.; east: Kuchinarai Gr.
PALEOZOIC	Permian	Paleotectonics; Drifting	Indochina at Equator 10° at L. Permian, Shan Thai at +/- 30-40°S during E. Permian & +/- 20°S during L. Permian	1.Indochina away from Aust. since E Carb. 2.Shan Thai with Aust. (E. Perm.) and rapid drift to Eq. (L. Perm) 3.L.Perm. narrow Paleotethys, & dev. of Mesotethys	Hercynian	shallow to deep marine	carbonate +/- chert, tuff, clastic	strong calc-alkaline volcanic arc; mild volcanism & gypsum dep.	moderate deform., Shan Thai-isoclinal folding, L. Perm. minor uplift, Indochina upthrust at W edge of Indochina	Paleotethys between Shan Thai and Indochina both closer in Late Permian
	Caboniferous					deep water marine, cold water transgression	clastic, rifted, diamictite (pebbly md+/- ss, sh)	Nakhonthai oceanic seafloor, Nadueng coal field, Cr+/-Ni, Cu		partly exposed Shan Thai (Uthai) & Indochina (Loei) landmass
	Devonian	Rifting	both blocks moving southward to low Latitude of S-hemisphere with clockwise rotation	Development of Lampang-Chiang Rai (LC) and Nakhon Thai (NT) blocks & Paleotethys during L. Devonian	Caledonian	deep water clastic sedimentation of sandstone+/- shale; rifting of E Shan Thai and W. Indochina	clastic and tuff +/- chert	calc-alkaline volcanics developed at active edges of both blocks	fold & thrust zones due to extensive volcanism & compression tectonics	+/- Lst. in W Indochina (Loei Area)
	Silurian						clastic and tuff			
	Ordovician	Accretion	both blocks situated at very low N. Latitude, Indochina at westside of Shan Thai, both showing anti-clockwise rotation	Gondwana low relief & peneplanation, gradual increase of marine transgression, weak metamorphism		deep water carbonate +/- fine clastic	red stromatolite lst. + shale	insignificant	open& asymmetrical folding with east-dipping axial plane	Shan Thai located near NW Australia Indochina (S&N China +/- Kurusegawa & S. Kitakami) near E. Australia
	Cambrian					shallow-marine sedimentation of ss. +/- shale	fine orthoquartzite + shale	insignificant		
PREPALEOZOI	Pre-Cambrian	Archaeotectonics; Block Formations	Shan Thai & Indochina blocks upside down, close to equator (Shan-Thai, W-Australia; Indochina-E. Australia)	both attached to Australia, multi-plate interaction, Amphibolitic (-Granulite) tectono-metamorphism	Pan-African; Duration; Intensity	shallow-marine accretion wedge on passive continental margins of both terranes	transgressive facies of clastic / non clastic (originally)	S - type granite & pegmatite small graphite deposit	intense folding, isoclinal, plastic to ptygmatic, strongly ductile deformation	Granulite metamorphic facies only in Indochina terrane outside Thailand, metamorphism during very early Cambrian-Late Paleozoic (Pan-African mobile belt)

Compression Extension

A) During Pre Cambrian and Cambro-Ordovician

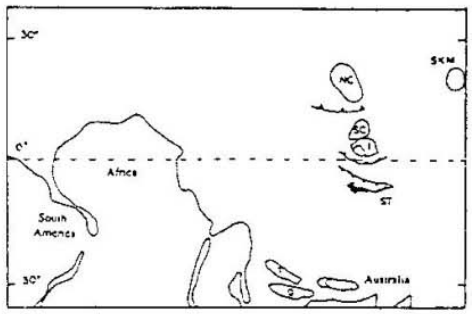


(modified from Grunow et al., 1996)

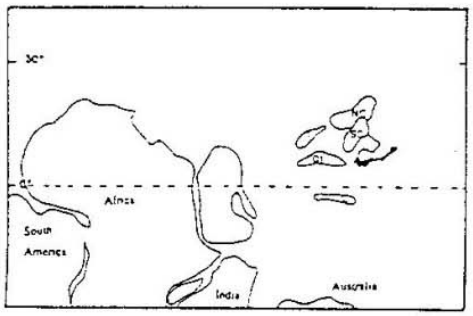


Cambro-Ordovician

C) During Late Permian to Late Triassic



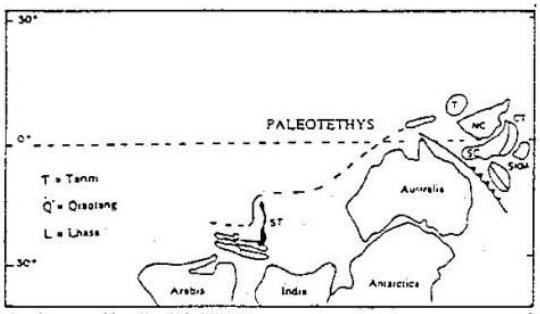
Late Permian



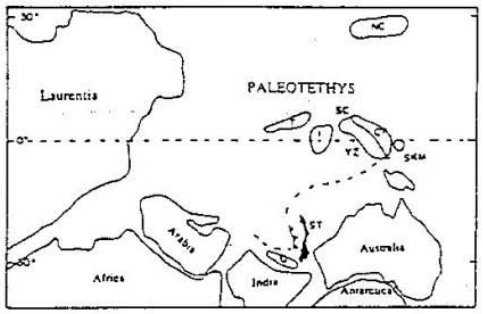
Late Triassic

D) During Late Jurassic to Late Cretaceous (modified from Metcalfe, 1996)

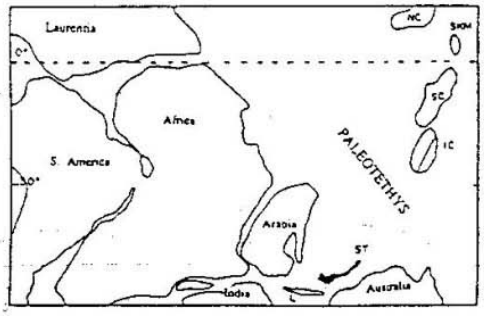
B) During Late Devonian to Early Permian



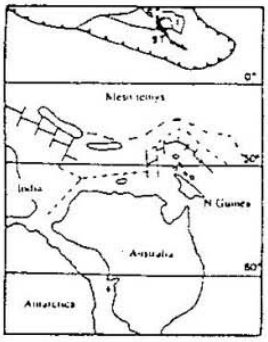
Late Devonian



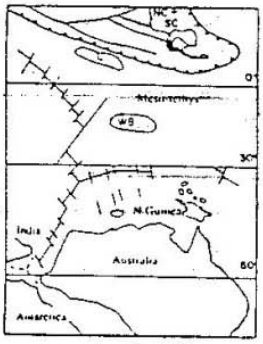
Early Carboniferous



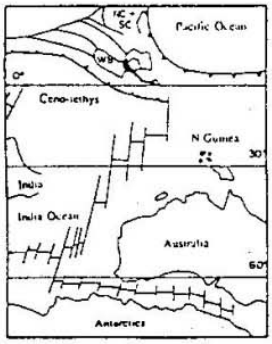
Early Permian



Late Jurassic



Early Cretaceous



Late Cretaceous

Figure 3 Plate tectonic reconstruction of Shan-Thai, Indochina and adjoining blocks.