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Tracing Disrupted Outer Margin of Paleoeurasian Continent through Union of Myanmar*

Myo Min Khin Khin Lin
Department of Geology, University of Mandalay, Mandalay, Myanmar
Feng Qinglai
Faculty of Earth Sciences, China University of Geosciences, Wuhan 430074
Chongpan Chonglakmani
School of Geotechnology, Suranaree University of Technology, Nakhon Ratchasima, Thailand
Dieter Meischner
Goettingen Center of Geosciences, University of Goettingen, Goldschmidtstr 3, D-37077 Goettingen, Germany
Ingavat-Helmcke Rucha
c/o Goettingen Center of Geosciences, University of Goettingen, Goldschmidtstr 3, D-37077 Goettingen, Germany
Helmcke Dietrich
Goettingen Center of Geosciences, University of Goettingen, Goldschmidtstr 3, D-37077 Goettingen, Germany

ABSTRACT

Based on stratigraphy, facies distribution and paleontology of upper Paleozoic and Triassic strata in Malaysia, Thailand, Myanmar and Yunnan (China), the location of the division between the outer margin of the disrupted Paleoeurasian continent and possible Gondwana-derived terranes is discussed. It is proposed that this division is located much further to the west than that has usually been maintained.
KEY WORDS Southwest Asia, Paleotethys, tectonic, boundary between Gondwana and Paleoeurasian continents.

INTRODUCTION

During the past two decades, a majority of geoscientists have regarded mainland Southeast Asia as composed of Gondwana-derived terranes which crossed "Paleotethys" to collide with the former Paleoeurasian continent in Late Triassic/Jurassic (Metcalfe, 1999; Scotese and Golonka, 1992; Sengör, 1979). The main branch of "Paleotethys" was believed to be situated either to the south of the Red River in northern Vietnam, or along the Nan-Uttaradit-Sa Kaeo-Bentong-Raub line in Thailand and Malaysia.

Many facts concerning the stratigraphy, the distribution of facies and the paleontology of northern Thailand, western Yunnan and the eastern parts of the Union of Myanmar were more or less ignored in these publications. This situation provoked criticism, and Helmcke (1985) proposed that the outer margin of the Paleoeurasian continent extended much further west, and included large parts of the Union of Myanmar. At that time, no conclusive evidence was known to us to define a possible terrane boundary between the regions in northern Thailand and eastern Myanmar which are composed of northern continental crust and those areas of mainland Southeast Asia which are characterized by the sediments of the Phuket Group and its equivalents (Singha Formation, Lebyin Formation, Mergui Group, Kongshuhe Formation).

Based on data from the region of Mae Sariang in northwestern Thailand, a possible terrane boundary between the margin of the Paleoeurasian continent and Gondwana-related terranes has been localized more precisely (Caridroit et al.,

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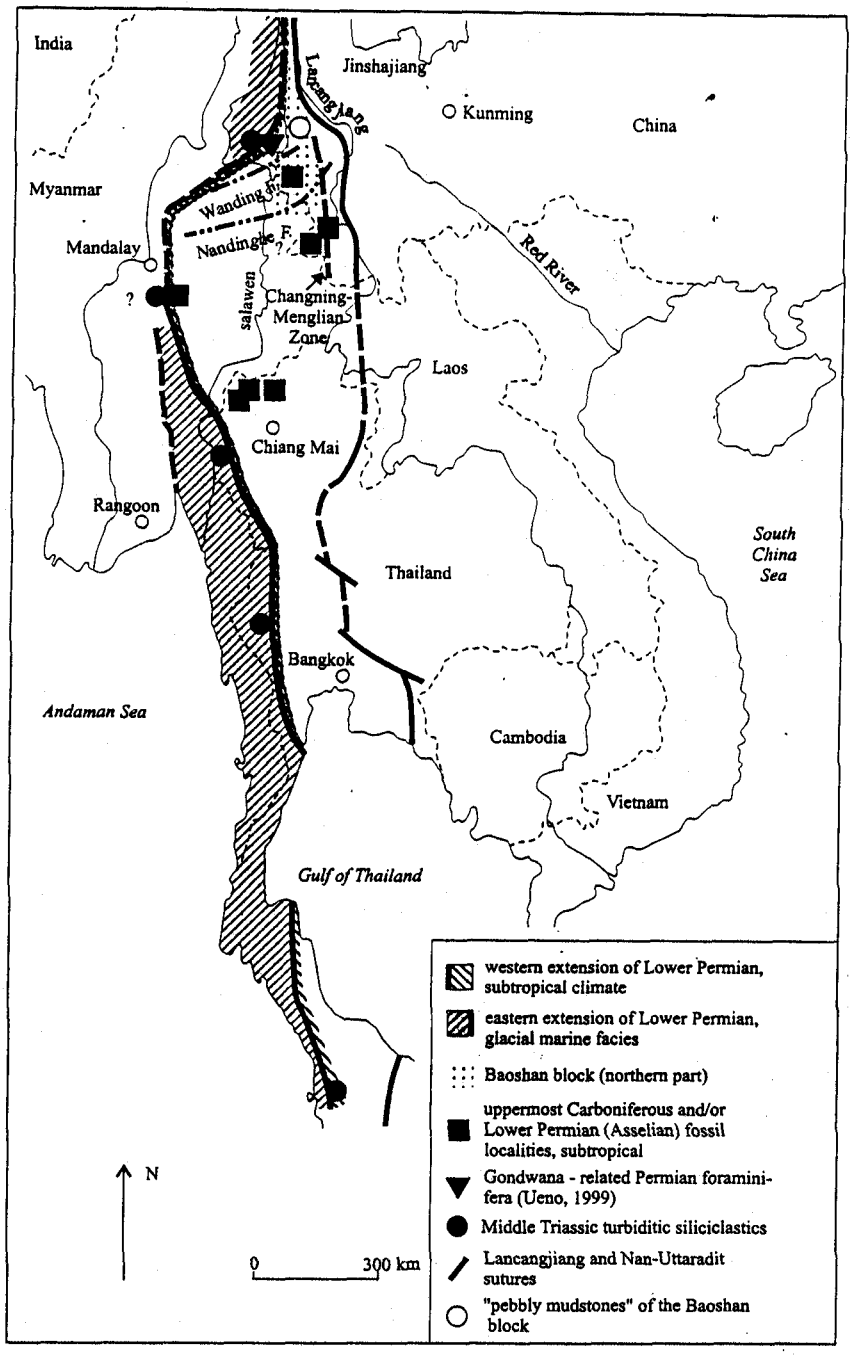

Figure 1. Proposed location of disrupted outer margin of Paleoeurasian continent.

1993; Helmcke et al., 1993; Töfke et al., 1993). However, in many areas of the Shan States of the Union of Myanmar, which are difficult to access, it is still quite problematic to trace this boundary. However, it is necessary to connect the known segments of this division in Malaysia and Thailand with its proposed position in western Yunnan.

In this contribution, we try to trace the outer margin of Paleoeurasia through the Union of Myanmar on the basis of previously published data (Fig. 1). However, a short evaluation of some paleogeographic terms appears necessary before the main arguments for the proposed location of the boundary are discussed.

CRITERIA FOR A CONTINENT/TERRANE BOUNDARY

The best arguments (Table 1), which can be used to trace this boundary, are based on the assumption that the different continents and surrounding continental shelves, which are today integrated into mainland Southeast Asia, were, during the Late Paleozoic, situated in quite different climatic zones. This is especially true for the uppermost Carboniferous and the lowermost Permian when the Permo-Carboniferous glaciation peaked in eastern Gondwana, while on the Yangtze platform, for example, tropical to sub-tropical conditions prevailed. Therefore, special reference will be made to climatic sensitive sediments and faunas of this period. This approach follows quite

strictly the original definition of "Gondwanaland" and "Angaraland" as introduced by Suess (1909, 1901, 1888, 1885, 1883), for this definition refers to the distribution of floras of Late Paleozoic, especially the Glossopteris-flora of "Gondwanaland".

In modern literature, however, the term "Gondwana" is often used to describe a super-continent configuration amalgamated during the "pan-African" orogenic event at approximately 0.55 Ga (Unrug, 1997), i.e. this term is used to describe a possible configuration of the continents at a time more than twice as long as the original definition requires. According to our conviction, however, this approach raises many problems. With respect to the region treated in this contribution: whether "pan-African" ages could be proved that it would help to trace the boundary or not (Zhong, 2000; Ren et al., 1999).

There remains a major problem: The original definition of the term "Tethys" (Suess, 1901) refers to the nature of the marine fauna of Mesozoic, and hence to a period different from the definitions of "Gondwanaland" and "Angaraland" (the continents bordering Tethys to the north and south). Therefore, since this term refers to a different period, it is questionable whether it can be applied correctly in this discussion. However, the first plate-tectonic reconstructions of the Late Paleozoic "Pangea"—configuration of the earth show the triangle-shaped ocean between eastern Gondwana and the former northern continents (Wilson, 1963), to which the term Tethys has been applied.

As discussed in many recent papers (Zhong, 2000; Yin et al., 1999; Liu et al., 1991), there still remains the possibility that this oceanic realm was an "Archipelagic ocean", i.e. an oceanic realm in which many smaller continental blocks were distributed at different latitudes, and separated from each other by oceanic crust. Such a model would also explain the strong facies variations between sedimentary sequences of the same age. The Indonesian archipelago may serve as a modern analogue. Therefore, observations which prove that an oceanic realm was still present during Middle Permian to Middle Triassic, between the Gondwana-related terranes and the non-Gondwana northern continental regions, are as equally important as the presence of sediments indicative of different climatic conditions on the respective continents and continental shelves.

TABLE 1 SIGNIFICANT FEATURES USED FOR DIVISION OF MAIN ELEMENTS OF SEASIA WITH EMPHASIS ON CARBONIFEROUS TO TRIASSIC (BASED ON WANG ET AL. (1997))

		Gondwana and Gondwana-derived terranes	Tethys (Paleotethys)	Northern continents and related terranes
Triassic	U			granites closure of Triassic rifts
	M		synorogenic clastics (flysch)	
	L		pelagic sediments	Upper Permian - Triassic rifting
Permian	U	*Shanita*	pelagic sediments	*Paleofusulina* Emeishan basalt *Verbeekina* Middle Permian synorogenic clastics (flysch)
	M	(oolithic limestone) first limestone		connection with arctic fauna realm (*Pseudoschwagerina*), limestones with massive corals and oolitic limestones Jambi Flora of Sumatra
	L	glacial marine sediments no fusulinids	pelagic sediments	
Carboniferous		*Glossopteris* flora		? *Walchia* *Paripteris* flora
pre-Carboniferous		granites with pan-African ages		

Detailed paleomagnetic investigations may provide a key to solve these problems. However, rocks from mainland Southeast Asia formed in Permian and Triassic, during this geodynamically crucial period, are most likely to have been affected by thermal overprinting during later periods. The results published by Richter et al. (1999) for Peninsular Malaysia and Langkawi Islands are not encouraging, nor are the conodont colour alteration data recently published by Metcalfe (2000). Similar problems are to be expected in northern Thailand and western Yunnan. Paleomagnetic data are therefore not consid-

ered in this paper.

For northern Thailand, Toriyama (1944), Konishi (1953) and Baum et al. (1970) have published convincing arguments, which exclude the possibility that the regions to the east of Mae Hong Son can be rightly regarded as "Gondwana"-related (Ueno and Igo, 1997; Fontaine et al., 1993), therefore, the suggestion for a possible position for "Paleotethys" along the Nan-Uttaradit line was, from the beginning, highly problematic (Helmcke and Lindenberg, 1983).

A more realistic solution was published by Cooper et al. (1989). They show a small sliver (Phuket Terrane) in Peninsular Thailand and in Myanmar as a separate terrane and interpret only this sliver as "Gondwana"-related. Brinckmann (Bender et al., 1983) and Mitchell (1992) also discussed a division of these regions from the regions further east. According to Mitchell (1992) and Brookfield (1996), the pebbly mudstone or diamictite unit (Phuket Group and equivalents) represents a distinct terrane.

LOCATION OF BOUNDARY SOUTH OF MYANMAR

In northern Malaysia, we locate the continent/terrane boundary to the west of the granites of the Main Range of Peninsular Malaysia, thus leaving only the Langkawi Islands and a narrow stretch of the Peninsula in the "Gondwana" realm. The main reasons for this decision are the nature of the Semangkol Formation and the age and nature of the granites of the Main Range and Penang Island.

The Semangkol Formation is described as an assemblage of Permian to Middle Triassic ribbon cherts and Middle Triassic siliciclastics, deposited by turbidity currents (Sashida et al., 1995; Spiller and Metcalfe, 1995). Therefore, this formation appears to be similar to the Triassic sequence known from Mae Sariang (northern Thailand) and an indicator of a former oceanic realm to the east of the Langkawi Islands, which host the Singha Formation (Stauffer, 1983). The granites of the Main Range of Peninsular Malaysia are mainly S-type and Triassic. This is, in contrast to the younger, mainly Cretaceous granites known, for example, from Phuket Island.

From northwestern Malaysia through Peninsular Thailand into northwestern Thailand, the exact location of the demarcation line is still little supported. However, the distribution pattern of the granites may help, as well as the distribution of sediments similar to the strata of the Phuket Group and associated Permian limestones, as described by Fontaine et al. (1994). These sequences are characterized by the lack of Lower Permian carbonates and low diversity faunas in the younger limestones (but with Shanita). There still remain some problems with the outcrops of "pebbly mudstones" near Surat Thani on the Peninsula (Lumjuan, 1993), and the interpretation of the granites in the region (Cobbing et al., 1992); according to our observations, however, these pebbly mudstones are lithologically similar to sediments typical of the Phuket Group.

A locality with Triassic siliciclastics, possibly deposited as turbidites was mentioned by Bunopas (1981) from localities along the river Khwae Yai some 40 km west of Kanchanaburi. Along the highway from Tak-Mae Sot in western Thailand, an outcrop of pelagic limestones of Triassic is known from 50 km (Fontaine and Suteethorn, 1988).

Probably the best outcrops of pelagic sediments, west of the margin of the former northern continent, can be studied in the surroundings of Mae Sariang in northwestern Thailand. Here, a Triassic sedimentary sequence of typical pre-orogenic and syn-orogenic strata is exposed, consisting of true ribbon cherts with abundant radiolaria, pelagic limestones with radiolaria and thin-shelled pelagic bivalves, overlain by a thick siliciclastic turbidite sequence. This flysch-type sequence contains *Posidonia*, *Halobia* and ammonites in the intercalated shales and is of Middle to Late Triassic (Töfke et al., 1993). In these strata, coarse siliciclastics derived from a high-grade metamorphic terrain which was probably situated to the east of Mae Sariang.

Continental red beds, which crop out west of Mae Sariang were formerly mapped as Lower-Middle Triassic strata, unconformably overlying Paleozoic sediments, and believed to form the basal layers of the above-mentioned pelagic sediments (Baum et al., 1981). Recent mapping and paleontological data, however, proved that these strata are younger (probably Jurassic). This conclusion derives from radiolarians of Permian and Triassic found in pebbles contained in these clastics (Caridroit et al., 1993). Based on this new evidence, the continental beds are interpreted as a post-orogenic overlap sequence. The regions east and west of Mae Sariang may have been on different plates or terranes prior to the Middle Triassic.

Tectonic units to the east of Mae Sariang are not Gondwana-derived terranes. This can be demonstrated in the region between Mae Hong Son and Pai in northern Thailand (Baum et al., 1970; Konishi, 1953; Toriyama, 1944). This region was restudied by Fontaine et al. (1993) who showed that shallow marine limestones were being deposited during most of the Carboniferous and Permian. These limestones show abundant indications of warm climatic conditions (lowermost Permian, for example: *Pseudoschwagerina* and compound corals). They were deposited on a stable platform which formed near the margin of the disrupted continent. Also the thick piles of mature arenites, deposited during parts of the Carboniferous (Fujikawa and Ishibashi, 2000) in this region, substantiate this interpretation.

LOCATION OF BOUNDARY IN MYANMAR

Pebbly mudstones from a narrow belt along the western edge of the Shan plateau are known as the Lebyin Formation and equivalents (Mitchell, 1992). According to available data and descriptions, the Lebyin Formation, as developed south of Mandalay (Maung, 1985, Fig. 15, Fig. 18), can rightly be compared with the strata of the Phuket Group in Peninsular Thailand or the Kongshuhe Group of the Tengchong block in western Yunnan. But such sediments are missing in Myanmar further to the east, where carbonates dominate.

The description by Garson et al. (1976) of the areas around Neyaungga and Yengnan, Southern Shan States, is of

special interest for the more precise location of the discussed boundary. Garson et al. (1976) mentioned a narrow belt composed of sediments, probably of Late Triassic (Ma-u-bin Formation), which stretches along the Pan Laung fault. This strip of probable Upper Triassic sediments may extend south to Kalaw and beyond (Garson et al., 1976, Fig. 4). The Ma-u-bin Formation does not occur anywhere else in this area. Garson et al. (1976) suggested that these strata are turbidites, which would be comparable to the Triassic siliciclastics in the area of Mae Sariang (Thailand) between Luxi and Ruili in western Yunnan. The age of the Ma-u-bin Formation is unfortunately not based on faunal evidence but only indirectly indicated by a good Rhaetian flora in coal seams intercalated in the overlying Loi-an Series. According to Mitchell (1992), the strongly deformed strata of the Ma-u-bin Formation are overlain unconformably by red beds of probably mid-Jurassic.

In east of the Pan Laung fault and the Triassic sediments, the Permian is characterized by a thick pile of carbonates (Thitsipin Limestone Formation) deposited under warm climatic conditions, as indicated by the occurrence of corals and typical fusulines. Garson et al. (1976) and Amos (1975) also described limestones of lowermost Permian age with *Pseudoschwagerina* from the Thitsipin Limestone Formation (Garson et al., 1976, Table 1, Table 2), thus confirming that the situation in the Southern Shan States is comparable to the situation in northern Thailand. However, most fossil-localities in the Thitsipin Limestone Formation are of upper Lower to Middle Permian age (including such characteristic fusulines as Verbeekina).

If the series near Mae Sariang are related to the Triassic strata described by Garson et al. (1976) along the Pan Laung fault, then the strip of glaciomarine sediments (Lebyin Formation and equivalents) continuously reduces in width to the north between the Pan Laung fault and the Shan Scarp until it reaches the region of Mandalay.

At present, it is still problematic to continue this boundary from the region of Mandalay further into western Yunnan, for the geology of the Northern Shan States is still little known. It is clear, however, that the boundary must turn sharply and rapidly away from Mandalay towards the northeast or east to enter western Yunnan. This sudden turn may be caused, or influenced by a strong younger (Himalayan) overprint.

LOCATION OF BOUNDARY IN WESTERN YUNNAN

In Yunnan, the trace of the "Paleotethys (mainbranch)" has been sought during the past decades along various "sutures". In recent years, however, most Chinese specialists (including Feng Q) decided to place this division along the "Changning-Menglian belt", east of the Baoshan block (Zhong, 2000; Fang et al., 1996). Some other authors (including Helmcke D and Ingavat-Helmcke R), however, favoured a position further west, i. e. possibly west of the Baoshan block along the Nujiang zone.

For both suggestions, good arguments are at hand and a final decision should be left open for the present. The main points of the controversity are the interpretation of the diamictites of the Dingjiazhai Formation on the Baoshan block and the occurrence of Lower Permian fusulines in this region. While the diamictites of the Kongshuhe Formation on the Tengchong block are very similar to those of the Phuket Group in Peninsular Thailand, those of the Dingjiazhai Formation on the Baoshan block differ strongly: They contain mainly pebbles of oolitic limestones, which are possibly derived from the local Carboniferous Pumenqian Formation (Heinemeyer, 1996; Jin, 1994). The distribution pattern of the Lower Permian fusulines is controversial, for *Pseudoschwagerina* (a typical Tethyan element) was found near Zhengkang on the southern Baoshan block (Wang et al., 1997), while Ueno (1999) reported Gondwana-related foraminifera (*Eopolydiexodina*, *Shanita*) from an area evidently also near Zhengkang. Apparently more detailed research is needed, and future cooperation between geologists from China and Myanmar in this matter is highly desirable.

From Landsat-image interpretation, a direct connection between the southernmost outcrops of the Changning-Menglian belt in China, and the region of the Pan Laung fault, south of Mandalay in the Union of Myanmar (as well as a direct connection with the region of Mae Sariang, Thailand), seems to some of us (Helmcke D) quite unlikely. This, however, is a weak argument, as long as it is not supported by extensive fieldwork. A direct connection between the Changning-Menglian belt and the outcrops along the Nan-Uttaradit zone, or with a "cryptic suture" in the region of Chiang Rai or Chiang Mai (as discussed in some papers) would only be possible, if this "suture" could be traced across the belt characterized by high-grade metamorphics associated with huge granite intrusions, which stretches from the Doi Inthanon region of Northern Thailand, via the eastern parts of the Union of Myanmar, to the Lincang region of southern Yunnan. Furthermore, the sections with the typical warm water sediments of Carboniferous and Permian, known between Mae Hong Son and Pai in northwestern Thailand, are in contradiction to this suggestion.

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