Tectonophysics 471 (2009) 329–332

Contents lists available at ScienceDirect

Tectonophysics

journal homepage: www.elsevier.com/locate/tecto

Discussion

Comment on "An alternative plate tectonic model for the Palaeozoic–Early Mesozoic Palaeotethyan evolution of Southeast Asia (Northern Thailand–Burma)" by O.M. Ferrari, C. Hochard & G.M. Stampfli, Tectonophysics 451, 346-365 (doi:10.1016/j.tecto.2007.11.065)

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ARTICLE INFO

Article history:
Received 1 April 2008
Received in revised form 22 December 2008
Accepted 26 January 2009
Available online 3 February 2009

Keywords:
Southeast Asia
Shan-Thai
Palaeo-Tethys
suture zone
Gondwana
Cathaysian

ABSTRACT

Ferrari et al. [Ferrari, O.M., Hochard, C., Stampfli, G.M., 2008. An alternative plate tectonic model for the Palaeozoic–Early Mesozoic Palaeotethyan evolution of Southeast Asia (Northern Thailand–Burma). Tectonophysics 451, 346–365. doi:10.1016/j.tecto.2007.11.065.] redefine the "Shan-Thai" terrane in Thailand as a Cathaysian Indochina-derived terrane when this has traditionally been defined and used as a Gondwana-derived continental block, hence introducing unnecessary confusion. In their definition of "Shan-Thai", they also inappropriately combine oceanic suture zone rocks (the Palaeo-Tethys Inthanon suture) and continental arc rocks (Sukhothai Island Arc system). The Mai Yuam Fault, identified by Ferrari et al. (2008) as the Palaeo-Tethys suture, is in fact a Cenozoic fault and the Palaeo-Tethys suture zone is represented by the Inthanon Suture zone in Thailand which is equivalent to the previously recognised Inthanon zone. The concept of derivation of "Orang Laut" terranes from South China-Indochina by back-arc spreading is innovative but the proposed Permo-Triassic back-arc along the Song Da/Song Ma zone in Vietnam is less convincing. There is little evidence to support the proposed southwards subduction of Palaeo-Tethys beneath eastern Gondwana in the Permian.

1. Introduction

Ferrari et al. (2008) present a new model for the geodynamic evolution of Southeast Asia in which they particularly focus on the northern Thailand–Burma region. Ferrari et al. claim to use a "modern plate tectonic model" for their reconstructions as compared to "classical continental drift models proposed so far". They also discuss the location of the Palaeotethys suture in Thailand, and propose the Tertiary Mae Yuam Fault to represent this suture. The "Shan-Thai" block is also re-defined in this paper and a new "Orang Laut terranes concept" is introduced. I have serious concerns with some of the interpretations presented by Ferrari et al., and also with their use of the term "Shan-Thai". I here present some discussion and alternative interpretations and comments on the geodynamic framework and evolution of Thailand and Southeast Asia and on what I consider to be inappropriate terrane definitions and terminology.

2. Plate reconstruction methodology and plate reconstructions

I congratulate Ferrari et al. (2008) on the general approach to plate and palaeogeographic reconstruction, particularly in using a quantitative based model that takes into account relative plate motions and velocities on a sphere in combination with a range of multi-disciplinary geological and geophysical data for the region that can be incorporated from GIS databases. I do however feel that it is an exaggerated claim that the authors are the first to use this "modern" approach and the various reconstructions of Scotese et al. (1999), Scotese (2004), Dercourt et al. (1993), Hall (2002), Rosenbaum et al. (2002), Torsvik and Cocks (2004), Golonka (2007) serve as a few examples of such previous approaches. In my own reconstructions of the SE Asian region (e.g. Metcalfe, 1988, 1991, 1994, 2002a, 2005, 2006), I have also taken a range of multi-disciplinary data into account, including quantitative data such as palaeomagnetism and isotope geochronology, and a range of other semi-quantitative and qualitative data including biogeographic, stratigraphic and sedimentological data. It has long been demonstrated that plate and palaeogeographic reconstructions based solely on quantitative data or solely on qualitative data can produce both inaccurate and highly misleading reconstructions and interpretations. I have been long convinced that a truly multi-disciplinary approach is essential and I

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doi:10.1016/j.tecto.2009.01.022

laud the authors for taking this approach. In undertaking wide-ranging multi-disciplinary approaches to plate and palaeogeographic reconstructions, care must be taken to critically evaluate the quality of all data used so as to avoid the "rubbish in–rubbish out" pitfall. Inconsistencies between different types of data must also be critically evaluated. Two examples come to mind, the Amorica problem, that led to intense debate between palaeomagnetists and biogeographers (Young, 1987) and the ongoing debate regarding the timing of the India–Asia collision (see Ali and Aichison, 2008 for an excellent discussion). Also, interpretations of quantitative data in isolation and without due credence to other relevant geological information can lead to erroneous interpretations (see Metcalfe, 1994 for some examples relating to palaeomagnetic data). Competing/alternative scientific models are always welcome, for these generate discussion, and hopefully further focused research to provide solutions to ongoing problems.

3. Use and abuse of the terms "Shan-Thai" and "Gondwana-Tethys/Cathaysia divide"

Ferrari et al. (2008) use the term "Shan-Thai" as a Cathaysian Indochina-derived continental block and claim this nomenclatural choice is used so as to not introduce confusing terminology. I suggest that this use of "Shan-Thai" as a Cathaysian continental block, when it was originally introduced and defined as a Gondwana-derived block by Bunopas (1982), will indeed cause further confusion!

The Sibumasu Terrane (Metcalfe, 1984) is the Gondwana-derived continental terrane in South East Asia that included parts of western Thailand, Burma, western Peninsular Malaysia and north-west Sumatra, characterised by the presence of Late Carboniferous and Early Permian glacial-marine diamictites and Late Palaeozoic strata with Gondwana affinity faunas and floras (see Metcalfe, 2005, Fig. 8). This terrane, as defined, is NOT equivalent to the Shan-Thai Terrane of Bunopas (1982) which was defined as including "eastern Burma, western Thailand and northwestern Malay Peninsula", but some workers have, and still continue to equate Shan-Thai with Sibumasu. It is here stressed that these are not equivalents and the terms should not be used interchangeably. Matters have been made worse recently with some proposals to apply the term "Shan-Thai" to include Cathaysian elements of Thailand (e.g. Hirsch et al., 2006; Ishida et al., 2006; Ferrari et al., 2008) introducing further confusion of the originally defined Gondwana Shan-Thai Terrane. The "Shan-Thai Block" of Hirsch et al. (2006) and "Shan-Thai" terrane of Ferrari et al. (2008) in fact include both continental terranes and suture zones (see Hirsch et al., 2006, Fig. 2; Ferrari et al., 2008, Fig. 5) which is an unacceptable oversimplification and composite grouping of very different tectonic units.

Confusion has also arisen relating to the major Late Palaeozoic biogeographic boundary recognised through East and Southeast Asia that separates Late Palaeozoic Gondwana faunas and floras from Cathaysian faunas and floras. This major biogeographic divide has been termed the "Gondwana-Tethys Divide" or "Gondwana-Cathaysia Divide" by some workers and has been used to mark the boundary between Gondwana derived continental terranes in the west, with Early Permian cold/cool climate sediments and biota, from warm climate equatorial Cathaysian continental terranes to the east (Ueno, 2003; Metcalfe, 2005). It was the recognition of this major biogeographic divide, coupled with Late Carboniferous–Early Permian diamictites interpreted to be of glacial-marine origin, that led to models of Gondwana dispersion and Asian accretion of terranes derived from Gondwana (e.g. Metcalfe, 1988, 1990). The Gondwana-Cathaysia biogeographic divide has been taken by some authors to indicate the boundary between Gondwana and Cathaysian continental terranes (e.g. Ueno, 1999; Ueno and Hisada, 1999, 2001) and also used to identify the position of the Palaeo-Tethys suture as corresponding to the Mai Yuam Fault in Thailand (Ueno and Hisada, 2001; Ueno, 2003; Ferrari et al., 2008). This is an unfortunate interpretation, because Cathaysian faunal elements in sea mounts occurring within the Palaeo-Tethys suture zone (Feng et al., 2008; Ueno et al., 2008) have been misinterpreted to indicate the suture lies further to the west. This is particularly illustrated by Hirsch et al. (2006, Fig. 2) who place the Gondwana-Tethys divide in Peninsular Malaysia west of stable continental margin limestones (Kanthan Limestone, Kinta Valley) which contain Gondwana faunas (Metcalfe, 1993, 2002b). Hirsch et al. (2006) also show a "Pattani Suture" in the Gulf of Thailand and extending into Peninsular Malaysia delineating the eastern margin of their "Mae Sariang Zone" yet there is no description of or justification for this suture zone provided.

4. Tectonic framework of Thailand–Burma and the Palaeo-Tethys suture in Thailand

Ferrari et al. (2008) interpret the main Palaeotethys suture to be located along the Tertiary Mae Yuam fault following the interpretations of Ueno (1999) and Ueno and Hisada (1999, 2001). The Mai Yuam Fault is a Cenozoic fault and there is no evidence that this represents the site of destruction of the Devonian-Permo-Triassic Palaeo-Tethys. Nor does it represent a suture line or suture zone as defined by Sengör and Natal'in (1996). The identification by Ferrari et al. of the Inthanon and/or Sukhothai zones as an Indochina-related continental terrane is also not new — this has been regarded by some workers as a southern extension of the Simao block of western China (e.g. Wu et al., 1995). Sone and Metcalfe (2008) have presented a new interpretation of the tectonic framework of Thailand (Fig. 1) and have proposed that the Inthanon Zone of Bunopas (1982) represents the Palaeo-Tethys suture zone and have now termed this the Inthanon Suture. The Nan-Uttaradit and Sra Kaeo sutures of Thailand (together with the Jinghong suture of SW China) are also interpreted as representing a closed back-arc basin. The Sukhothai zone of Bunopas (1982) is interpreted as the core of a Cathaysian Permian island arc system (comprising the Lincang, Sukhothai and Chanthaburi terranes) developed on the western margin of the Indochina terrane. Ferrari et al. (2008) include both the Inthanon zone and Sukhothai zone as constituting their Indochina-derived "Shan-Thai" terrane. As stated above, this is an unacceptable usage of the term "Shan-Thai" and the grouping of the Palaeo-Tethys suture zone and a continental island arc (or Indochina-derived continental terrane), which are in tectonic and genetic terms quite different, as a single terrane, will undoubtedly lead to enhanced confusion.

5. Orang Laut terranes

Ferrari et al. (2008) propose an "Orang Laut terranes concept" which suggests back-arc induced break-up of the South China–Indochina superterrane to produce what the authors call "Orang Laut terranes". I welcome this concept which has merit in explaining some of the anomalies that have plagued us in Sumatra and Indochina for some time. The concept is however not entirely new. The recognition of a West Sumatra terrane of Cathaysian origin, outboard of the Sibumasu terrane in Sumatra by Hutchison (1994) and Barber and Crow (2003) led to models that derived this terrane from "Cathaysialand" (combined South China–Indochina–East Malaya composite terrane in Permo-Triassic times) by Barber et al. (2005) and Metcalfe (2005, 2009). Furthermore, West Burma has recently been identified as a probable Cathaysian terrane, originally contiguous with West Sumatra but now separated by the Andaman Sea (Barber and Crow, 2008). Ferrari et al. (2008) quite rightly identify northern Vietnam as a key area for enhancing our understanding of SE Asian terrane evolution and palaeogeography. I have previously argued for a Carboniferous amalgamation of Indochina and South China along the Song Ma zone. Biogeographic similarities in the Devonian (non-marine fish faunas) do not necessarily imply that Indochina and South

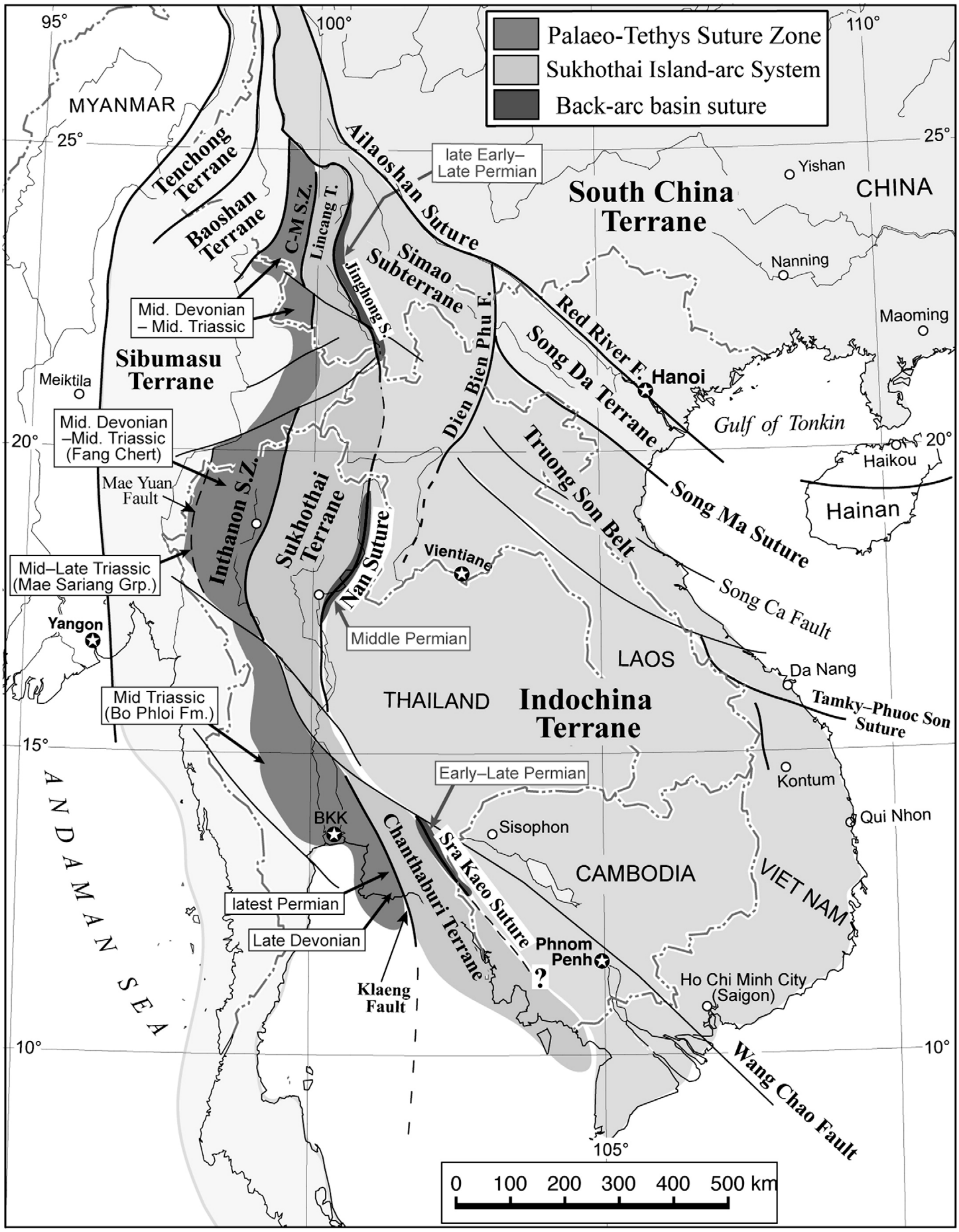

Fig. 1. Tectonic subdivision of mainland Southeast Asia, showing the Palaeo-Tethys Suture Zone (Inthanon Suture) and back-arc sutures (Jinghong, Nan and Sra Kaeo). The occurrence of deep-sea sediments in each local suture is indicated. C–M S.Z. = Changning–Menglian Suture Zone. From Sone and Metcalfe, 2008.

China had already collided along the Song Ma zone. Palaeogeographic reconstructions that place both Indochina and South China on the NE margin of Gondwana in the Devonian (e.g. Metcalfe, 2005) easily explain these similarities. Further work is required to demonstrate that there was indeed a back-arc oceanic basin or basins developed along the Song Da/Song Ma zone in the Permian-Triassic rather than an intracratonic rift zone. Derivation of the Spratlys and parts of the Philippines from the Indochina margin by back-arc spreading is certainly a possibility, but whether West Sumatra, West Burma and SW Borneo (Kalimantan) were derived in this way requires further investigation. SW Borneo has recently been proposed as a Gondwana-derived continental fragment that represents "Argoland" that separated from NW Australia in the Jurassic (Hall, in press; Hall et al., 2008; Metcalfe, 2009).

6. South-directed subduction beneath eastern Gondwana in the Carboniferous-Permian

I find the suggestion by Ferrari et al. (2008) of southwards directed subduction beneath eastern Gondwana (beneath Sibumasu) in the Permian (290–250 Ma) less than convincing. The Upper Carboniferous volcanics of the Lhasa terrane referred to are more likely related to the rifting episode that led to separation of the Cimmerian continental strip rather than a subduction produced volcanic arc. There is no other unequivocal evidence for a subduction related volcanic arc on the eastern Cimmerian continent (including Sibumasu). The flow-on interpretation by Ferrari et al. (2008) to invoke (unnecessarily in my opinion) a "plate limit" between west and east Palaeotethys is highly conjectural.

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