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ScienceDirect
C. R. Geoscience 340 (2008) 893–895
COMPTES RENDUS GEOSCIENCE
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Commentary

Comment on *Was the Indosinian orogeny a Triassic mountain building or a thermotectonic reactivation event?* by A. Carter and P.D. Clift [C. R. Geoscience 340 (2008) 83–93]☆

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In a recent paper, Carter and Clift [1] put forward a new plate evolution model for southeastern Asia based on a redefined Indosinian tectonic event, which was previously used to describe Triassic orogeny across China and southeastern Asia. They referred to the Indosinian orogeny as a thermotectonic reactivation event that was confined to the Vietnamese territory stemming from accretion of Sibumasu to Indochina in the Triassic, assuming that welding between Indochina and South China had been completed in the Silurian. Meanwhile, they attributed Triassic magmatism, metamorphism and deformation in South China to subduction of the Paleo-Pacific oceanic plate under South China. Whilst their ideas about the Indosinian orogeny are creative, we question their tectonic model for southeastern Asia, based on the following reasons.

Carter and Clift [1] proposed that welding between South China and Indochina occurred in the Silurian. However, we have to point out that numerous outcrops of mafic and ultramafic rocks are exposed in Yunnan, Guangxi, and Hainan provinces of southernmost China bordering Vietnam. These basic and ultrabasic rocks are generally Devonian-Early Triassic in age [7,8,24] and have clear mid-oceanic ridge affinity [14,33]. Clearly, they represent fragments of ophiolites and have been proposed to define a Paleo-Tethyan suture zone between the South China and Indochina blocks [16,25]. This fundamental fact indicates that China and Indochina could not have been amalgamated together until the Triassic and that an oceanic environment could have existed between these two continental blocks during the Late Paleozoic. An Indochina-South China collision in the Late Triassic are best indicated by intense Late Triassic contractional deformation across the suture [7,8,24], a regional unconformity located between the Upper and Middle Triassic, and termination of marine deposition at the end of the Middle Triassic and accumulation of huge Upper Triassic continental red beds [3,5,7,8,24].

Carter and Clift's Silurian South China-Indochina collision model [1] was mainly based on the geologic fact that some Givetian–Frasnian aged freshwater fish faunas from terrigenous deposits were discovered in Vietnam and South China [19,20]. Actually, however, these endemic fish faunas have also been widely discovered across South-North China and Tarim [31], and, moreover, paleontologic and sedimentary evidence even reveals close affinity of South China with Indochina during the entire Early Paleozoic [18]. Therefore, an alternative possibility is that Indochina and South China could never have been separate until the Late Paleozoic when they were detached away from Gondwana [18]. The same paradox can also be applied to the granitoids of 400–450 Ma. These granitoids are distributed not only on either side of the Song Ma

☆ DOI of original article: 10.1016/j.crte.2007.08.011.
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1631-0713/$ – see front matter
doi:10.1016/j.crte.2008.09.004

fault zone (e.g., in Kontum, Song Chay and Yunkai) but also across South-North China and Tarim [11,17,21,22,26,28]. More precise radiometric and geochemical work needs to be carried out to constrain the geological significance of these granitoids.

Carter and Clift [1] also attributed Triassic magmatism, metamorphism and deformation in South China to subduction of the Paleo-Pacific oceanic plate under South China. The subduction as early as the Middle Permian [13,15] adopted by Carter and Clift [1] seems to conflict with following geologic facts.

The deposition in southeastern China from the Early Permian to Middle Triassic is strictly continuous and there are no noticeable sedimentary hiatuses or regional angular unconformities in this temporal interval [6,7,10,12,32]. Moreover, the fold and thrust structures in this area do not share the same vergence and deformation age. For example, the contraction deformation in the Yangtze plate on the Northwest of the Jiangnan orogen verged toward the northwest [27,29,30] and involved the Lower Cretaceous [23], while the compressional deformation in the southeastern margin of China verged toward the southeast and involved the Lower Triassic [2].

Triassic granites are sporadically distributed in the southeasternmost margin of China and are dominated by strongly peraluminous S-type granites [34], diagnostic of syn-collision mountain-building setting. In addition, Triassic metamorphism and plutonism do not have a simple inland younging trend across this region (see [4] for detail).

Carter and Clift [1] related the calc-alkaline I-type granites of 267–262 Ma in southern Hainan Island to subduction of the Pacific oceanic plate. However, there is another possibility that these granites were related to the Paleotethyan south-directed subduction. This subduction is marked by a suture within Hainan Island, southern China, which yields 333 Ma-aged ophiolites that were emplaced during the Early Mesozoic [14].

Carter and Clift [1] have already indicated that the Nanpanjiang basin is a key region to interpreting the Indosinian tectonic event. However, we point out that their interpretation of the paleogeography of the basin is questionable in the tectonic reconstruction. We agree that there are NW- to west-directed palaeocurrents [5,9] in Triassic turbidites of the basin, but we believe this reveals the presence of an uplifted belt related to the diachronous continental collision between Indochina and South China, rather than related to subduction of the Palaeo-Pacific oceanic plate as proposed by Carter and Clift [1]. However, on the southern margin close to the border areas between China and Vietnam, north- or NE-directed palaeocurrents also exist, such as in Napo. This indicates a southerly provenance from northern Vietnam. In addition, Middle Triassic turbidites are up to 8000 m thick in this basin and Upper Triassic continental red beds are up to 7561 m in the eastern and western margins of the basin [8]. Furthermore, as mentioned above, there are numerous ophiolitic fragments in the basin. These lines of evidence all indicate the Triassic is not a tectonic quiescence in the Nanpanjiang basin and the Indosinian tectonic event is not restricted to Indochina.

To conclude, there is no evidence for a Silurian collision between South China and Indochina. Furthermore, the sedimentation and metamorphism in Indochina and the Nanpanjiang basin indicate their welding could have occurred during the Triassic. The Paleo-Pacific subduction beneath South China could have contributed to the deformation, metamorphism and magmatism in southern China but these should have taken place after the Middle Triassic or much later in the Late Jurassic [34]. This can be evidenced by the continuous marine deposition in the area from the Permian to the Middle Triassic [6–8] and the absence of subduction-related magmatism during the entire Triassic through the Early Jurassic [6–8,34]. Perhaps, Indochina was not far away from South China since the Late Paleozoic when they were separated from Gondwana. But this does not mean that these two blocks had coalesced together during the Devonian to the Carboniferous as proposed by Metcalfe [18], because no depositional hiatus exists in this area during this temporal interval [7,8]. These two continents could have amalgamated together in the Late Triassic, marked by closure of the Song Ma belt and death of the Nanpanjiang basin.

Acknowledgements

We thank Dr Kai-Jun Zhang for constructive discussion and two anonymous journal referees for thoughtful review comments, which greatly improved the manuscript.

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