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The volcaniclastic series from the Luang Prabang Basin, Laos: A witness of a triassic magmatic arc?

Camille Rossignol [a,b,*], Sylvie Bourquin [a], Marc Poujol [a], Erwan Hallot [a], Marie-Pierre Dabard [a], Thierry Nalpas [a]

[a] Géosciences Rennes, UMR CNRS 6118, Université de Rennes 1, OSUR, Campus de Beaulieu, 263 Avenue Leclerc, 35042 Rennes Cedex, France
[b] GéoHydrosystèmes Continentaux, EA 6293, Université François Rabelais, Tours, Campus de Grandmont, 30 Avenue Monge, 37200 Tours, France

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ABSTRACT

The paleogeographic evolution of South East Asia (SEA) during the early Mesozoic is still poorly understood and a number of models have recently been put forward to account for the geodynamic evolution of SEA. The Luang Prabang Basin (north Laos), located in the core of a "paleogeographic jigsaw" in SEA, recorded a long lasting volcanism that spanned for ~ 35 my from the earliest Triassic up to Late Triassic as evidenced by combined stratigraphic and geochronological (U–Pb/zircon) analyses performed on both volcanic and volcaniclastic series. The volcanic rocks are arc tholeiites and calk-alkaline andesites to dacites. The volcaniclastic rocks contain, in part, volcaniclasts produced contemporaneously with sedimentation. Both the volcanic and volcaniclastic series display geochemical features characteristic of a subduction related volcanism. Therefore, the Luang Prabang Basin documents a magmatic arc in a good agreement with the recent recognition of neighboring ophiolitic rocks in the Luang Prabang area. Following a passive margin setting that prevailed from the late Carboniferous to the late Permian, an active margin then initiated along the western margin of the Indochina Block. This active magmatic arc developed as the result of an east-dipping subduction below the Indochina Block during most of the Triassic, at least from ca. 250 to 215 Ma. Subsequently, this oceanic subduction episode must have been followed by a continental collision of the Indochina Block with the eastern Simao Block, at a period that remains to be defined.

1. Introduction

The present day South East Asia (SEA) largely results from collisions between several continental blocks (e.g., the Sibumasu, Simao, Indochina and South China blocks, Fig. 1A) and volcanic arcs (e.g., Sukhothai arc, Fig. 1A) during the Triassic and Jurassic periods (e.g., Barr et al., 2006; Mitchell et al., 2012; Peng et al., 2013; Zaw et al., 2014; Burrett et al., 2014; Lai et al., 2014a and references therein). The exact number of continental fragments and volcanic arcs that actually compose SEA, as well as the timing of their amalgamation, are still controversial and a number of geodynamic models have been proposed to account for the tectonic evolution of the east Tethyan domain (e.g., Ridd, 1971; Burrett, 1974; Sengör, 1979; Mitchell, 1981; Helmcke, 1985; Metcalfe, 1988, 2002; Lepvrier et al., 2004; Ferrari et al., 2008; Carter and Clift, 2008; Cai and Zhang, 2009; Metcalfe, 2011; Liu et al., 2012; Cocks and Torsvik, 2013; Lai et al., 2014b; Qian et al., in press). Corollary to these uncertainties about the geodynamic evolution of SEA from the late Paleozoic to the early Mesozoic, the spatial configuration (i.e., the shape) of the blocks that compose the east Tethyan domain and the nature of their boundaries are not precisely known (e.g., Heppe et al., 2007; Q. Wang et al., 2014).

Despite the fact that the Simao Block encompasses a relatively large geographic area with a triangular shape in south China (western Yunnan) and northern Laos (Fig. 1A), its paleogeographic affinity is poorly constrained. This block was initially recognized by Wu et al. (1995), and is sometimes considered as an independent continental block prior to the Late Triassic (e.g., Wu et al., 1995; Metcalfe, 2002; Wakita and Metcalfe, 2005). For instance, Kamvong et al. (2014) suggested that the Simao plate was independent before it collided with, and was integrated into, the eastern Indochina Block during the late Carboniferous. Contradictorily with the existence of this independent plate, the Simao Block is

* Corresponding author at: Géosciences Rennes, UMR CNRS 6118, Université de Rennes 1, OSUR, Bât. 15, Bur. 207/2, Campus de Beaulieu, 35042 Rennes Cedex, France.

E-mail addresses: camil.rossignol@gmail.com (C. Rossignol), sylvie.bourquin@univ-rennes1.fr (S. Bourquin), marc.poujol@univ-rennes1.fr (M. Poujol), erwan.hallot@univ-rennes1.fr (E. Hallot), marie-pierre.dabard@univ-rennes1.fr (M.-P. Dabard), thierry.nalpas@univ-rennes1.fr (T. Nalpas).

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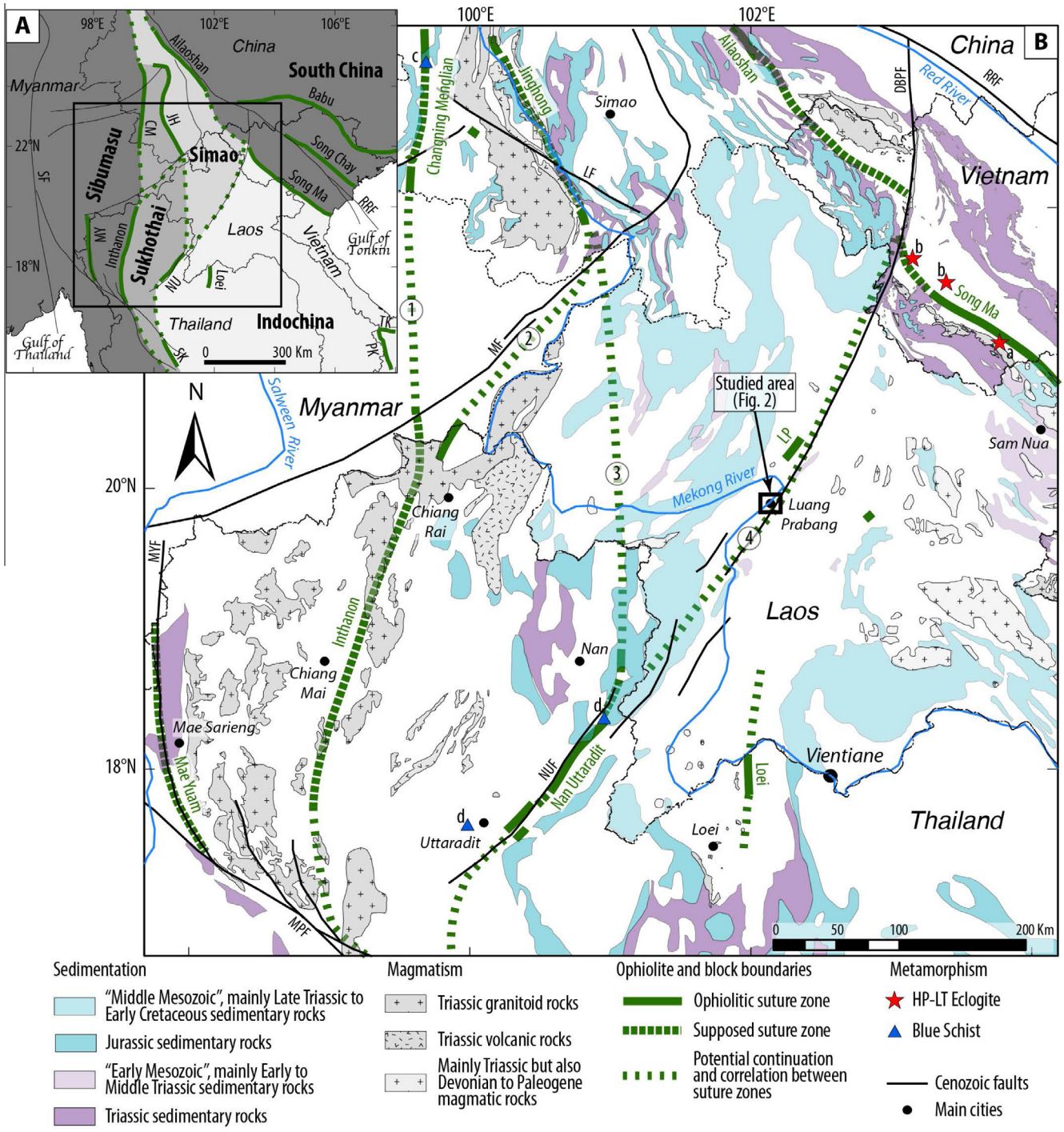

Fig. 1. Tectonic subdivisions and simplified map of the Triassic and Jurassic deposits in South East Asia. (A) Tectonic subdivisions of South East Asia, after Metcalfe, 2011. Other tectonic subdivisions have been proposed, see Ferrari et al., 2008; Barr et al., 2006; Ridd, 2014; Burrett et al., 2014; Zaw et al., 2014. Bold box refers to the area enlarged in figure (B). (B) Simplified regional tectonic map and distribution of Triassic and Jurassic sedimentary and magmatic rocks. Compilation after various sources; geological background after the geological map of Laos (1: 1 500 000; United Nations publication, 1990), the geological map of the Yunnan Province (1: 500 000; Bureau of Geology and Mineral Resources of Yunnan Province, 1990), the geological map of Thailand (1: 2 000 000, Ridd et al., 2011; Morley et al., 2011), and 5 geological maps of north Vietnam at the 1: 200 000 scale: Tuyet et al., 2005a (Khi Su – Muong Te); My et al., 2004 (Kim Binh – Lao Cai); Son et al., 2005 (Muong Kha – Son La); Tuyet et al., 2005b (Phong Sa Ly – Dien Bien Phu); Bao et al., 2004 (Van Yen). Major Cenozoic faults: MYF: Mae Yuam Fault, MPF: Mae Ping Fault, MF: Menxing Fault, NUF: Nan Uttaradit Fault, LF: Lincang Fault, DBPF: Dien Bien Phu Fault, RRF: Red River Fault, SF: Sagaing Fault. Suture zones (definite or supposed): CM: Changning Menglian, JH: Jinghong, LP: Luang Prabang; SK: Sra Kaeo, NU: Nan Uttaradit, PK: Poko, TK: Tamky. Metamorphic ages: a: 230.5 ± 8.2 Ma, U–Pb/zircon, Zhang et al., 2013; b: 243 ± 4 Ma, Th–U–Pb/monazite, Nakano et al., 2010; c: 294 ± 1 Ma, Ar–Ar/phengite, Heppe et al., 2007; d: 269 ± 12 Ma, K–Ar/actinolite; Barr and MacDonald (1987). Circled numbers refer to various hypotheses proposed about the spatial continuity of suture zones in order to correlate the ophiolitic segments together. See text for explanation.

sometimes considered as belonging to the Indochina Block (e.g., Ferrari et al., 2008; Q. Wang et al., 2014), while Sone and Metcalfe (2008) considered it as a "semi-detached portion" of the Indochina Block. Another hypothesis by Barr et al. (2006), reasserted by Qian et al. (in press), postulates that the Simao Block was part of a larger continental unit (called the Sukhothai Block by Barr et al., 2006) that includes both the Simao and the Sukhothai blocks, as depicted in Fig. 1A.