Gondwana Research xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Gondwana Research

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

Paleotethyan evolution of the Indochina Block as deduced from granites in northern Laos

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ARTICLE INFO

Article history:
Received 17 August 2015
Received in revised form 10 November 2015
Accepted 11 November 2015
Available online xxxx

Handling Editor: Y.P. Dong

Keywords:
Granite
Laos
Zircon U–Pb age
Lu–Hf
Whole-rock major
Trace and rare earth elements

ABSTRACT

The Paleotethyan evolution of the Southeast Asia has become better understood in recent years. Questions remain, however, over the role of the Dien Bien Phu Suture Zone in the evolution of the Indochina Block and whether the Song Ma Suture represents the boundary between the Indochina Block and the South China Block. Granitoid geochronological and geochemical data obtained in northern Laos provide new information vis-à-vis these arguments. Zircon U–Pb ages together with whole rock, trace and rare earth element data from 27 granitic rocks from five complexes allow us to conclude that these granites are typical of I-type Indosinian volcanic arc granites. However, the 234–256 Ma I-type granites mismatch the initiation age obtained from the ductile shear zone of the Dien Bien Phu Fault, thus repudiating the existence of the Dien Bien Phu Suture Zone. This then implies that the Qamdo–Simao and Indochina blocks were united. The geochemical and geochronological data further suggest that the main crust in the Indochina Block formed in the Late Paleoproterozoic to Early Mesoproterozoic, much later than the Archean crustal formation age identified east of the Song Ma Suture. Moreover, the 440–404 Ma and 234–256 Ma I-type granites suggest that the boundary between Indochina and South China should be the Jinsha River Suture–Song Ma Suture–Kontum Massif, instead of the Jinsha River Suture–Song Chay Suture. Finally, the Emeishan basalt and granite complexes both form part of the South China tectonic units subducting westward under the Qamdo–Simao and Indochina blocks.

1. Introduction

Mainland Southeast Asia is formed of several micro-continents (e.g., the Sibumasu, Indochina, Qamdo–Simao and South China blocks) which amalgamated during the closure of the Paleotethyan Ocean from the Late Permian to the Early Triassic (e.g. Sengör, 1979; Metcalfe, 1996, 1999; Carter et al., 2001; Metcalfe, 2002; Ueno, 2003; Lepvrier et al., 2004; Ferrari et al., 2008; Lepvrier et al., 2008; Liu et al., 2012; Metcalfe, 2013; Faure et al., 2014). Though increasing level of details about the Paleotethyan evolution of the SE Asia has been defined in recent years, arguments remain about the welding of the blocks in Southeast Asia. For example, new studies have confirmed that the Changning–Menglian and Inthanon suture zones can be regarded as part of the Paleotethys Suture Zone, and that the Jinghong–Luang Prabang–Nan–Sra Kaeo Suture can be treated as a closed back-arc basin (e.g., Sone and Metcalfe, 2008; Metcalfe, 2013; Qian et al., 2015). However, uncertainty remains about the role of the Dien Bien Phu Suture (where the Dien Bien Phu fault is developed) in the Paleotethyan evolution of Southeast Asia (Fig. 1). Establishing this would help determine whether the Qamdo–Simao Block is part of the Indochina Block, or if the Indochina and the Qamdo–Simao blocks are two separate blocks. This question has perplexed geologists for a long time (e.g., Metcalfe, 1996; Wang et al., 2000; Carter et al., 2001; Metcalfe, 2002, 2006). One view insists that the Sukhothai Arc and the Inthanon Suture correlate with the Lincang–Jinghong Volcanic Belt and the Changning–Menglian Suture in Yunnan, China (e.g., Sone and Metcalfe, 2008; Metcalfe, 2013). Taking this view, the Qiangtang–Baoshan Block west of the Inthanon Suture would form the northern part of the Sibumasu Block, and the Qamdo–Simao Block east of the Suture would represent the northern continuity of the Indochina Block (e.g. Wang et al., 2000; Carter et al., 2001; Carter and Clift, 2008; Ferrari et al., 2008; Liu et al., 2012; Faure et al., 2014). However, others argue that the Nan Suture bends northeastward at the Dien Bien Phu Segment and joins the Song Ma Suture, separating the Nan Suture from the Changning–Menglian Suture by hundreds of kilometers (Sengör, 1979; Leloup et al., 1995; Singharajwarapan and Berry, 2000; Lepvrier et al., 2004, 2008). Another question concerns the time and geometry of plate convergence prior to collision between the Indochina and the South China blocks. Paleogeographic evidence suggests a connection between Indochina and South China up to the Carboniferous (e.g. Hutchison, 1989; Metcalfe, 1996; Janvier et al., 1997; Metcalfe, 2002; Racheboeuf et al., 2005, 2006; Metcalfe, 2013), but syn-tectonic magmatic and metamorphic data

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http://dx.doi.org/10.1016/j.gr.2015.11.011
1342-937X/

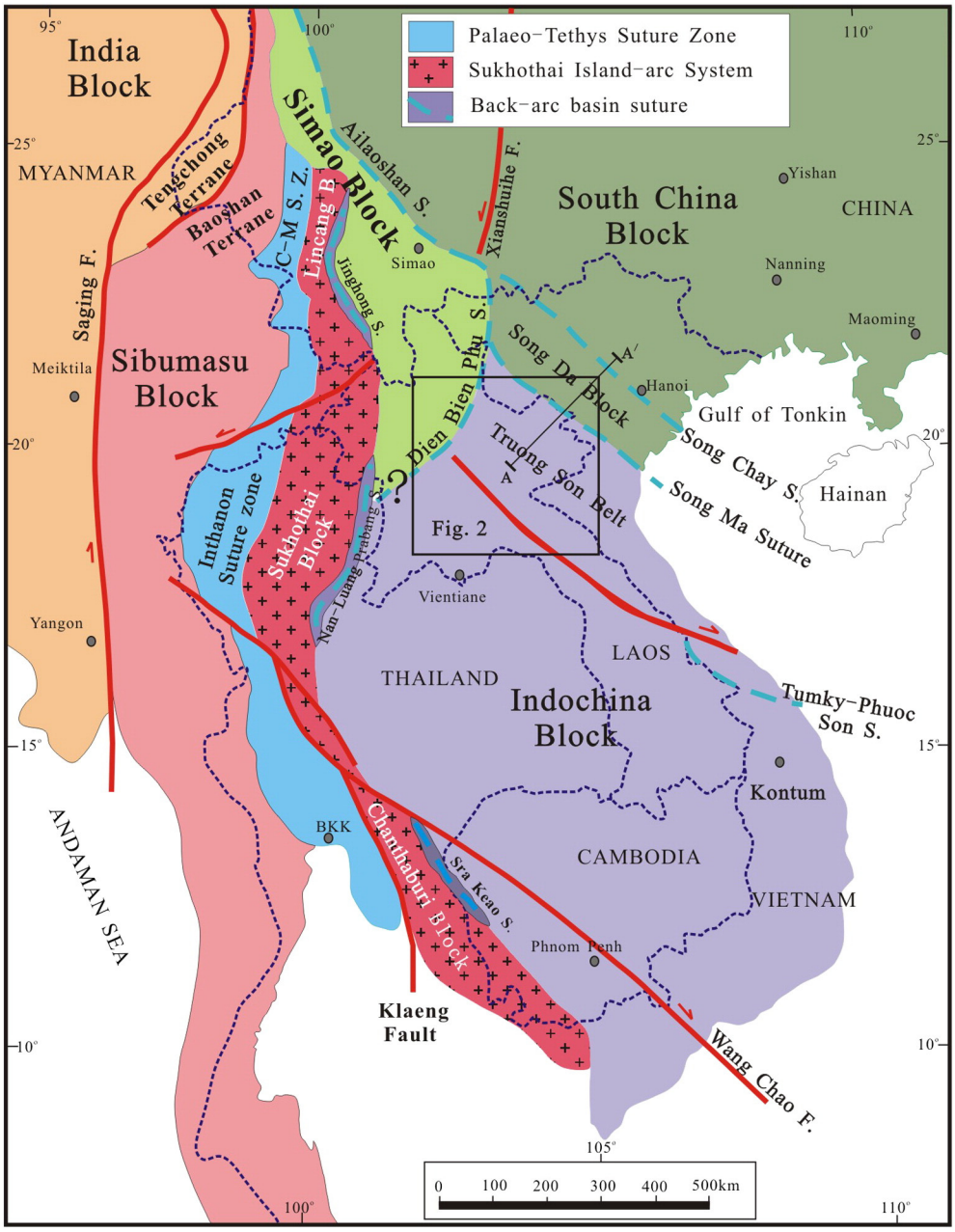

Fig. 1. Distribution of principal continental terranes and sutures of mainland Southeast Asia (after Sone and Metcalfe, 2008). CMSZ = Changning–Menglian Suture Zone; the locations shown in Figs. 2 & 3 are also shown.

show that a tectono-thermal event occurred between 260 Ma and 240 Ma (e.g. Lepvrier et al., 1997; Lan et al., 2000; Nagy et al., 2001; Lan et al., 2003; Lepvrier et al., 2004; Nakano et al., 2007; Owada et al., 2007; Lepvrier et al., 2008, 2011; Sanematsu et al., 2011; Lai et al., 2014). Additionally, varying opinions about the geometry of block convergence prior to collision exist, and include: 1) the eastward subduction of the Indochina Block beneath the South China Block (Lepvrier et al., 1997; Lan et al., 2000; Lepvrier et al., 2004); 2) the westward (or southward in a paleogeographic sense, as below) subduction of the South China Block beneath the Indochina Block (Liu et al., 2012; Faure et al., 2014); and 3) the existence of a pair of subduction zones dipping in opposite directions (Lepvrier et al., 2008).

Most areas of Laos are covered by virgin forest, which makes tracking the outcrops of the Dien Bien Phu ophiolitic suture difficult. Fortunately, granitoids are distributed broadly along the road from Phonsavan to Sam Neua in northern Laos, south of the junction between the Dien Bien Phu Suture and the Song Ma Suture (Fig. 2). It is widely accepted that the geochronological and geochemical data of granitic rocks can provide important information regarding the crustal evolution of tectonic plates. The geochronology and geochemistry of granitic rocks in northern Laos, however, are poorly known, due to their inaccessibility. In recent years we have collected more than 100 samples from different granitoid complexes in northern Laos in order to reconstruct the convergence processes of Southeast Asian blocks during the closure of the Paleotethyan Ocean.

2. Geological setting

2.1. The rocks in northern Laos

Proterozoic to Quaternary strata outcrop in central-northern Laos (Department of Geology and Mine, Lao P.D.R. (DGM), 1991; Fig. 2), and can be divided into three main units: Late Paleozoic, Early Mesozoic and Late Mesozoic. Late Paleozoic strata are mainly shallow sea-shelf

Please cite this article as: Wang, S., et al., Paleotethyan evolution of the Indochina Block as deduced from granites in northern Laos, Gondwana Research (2016), http://dx.doi.org/10.1016/j.gr.2015.11.011