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Petrogenesis of middle Ordovician peraluminous granites in the Baoshan block: Implications for the early Paleozoic tectonic evolution along East Gondwana

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ABSTRACT

Peraluminous granitic magmatism in the Baoshan block is long-lasting roughly from 500 Ma to 450 Ma. The petrogenesis and geodynamics for this long-lived magmatism remain controversial. To address this controversy, this study reports the zircon U–Pb age and Hf-isotope, and bulk-rock major and trace element data of the granites from the Shuangmaidi and Mengmao areas in the Baoshan block. LA-ICPMS zircon U–Pb dating reveals that the granitic rocks from the two areas were emplaced between 470 and 459 Ma. These rocks are high silicic and strongly peraluminous, with SiO_2 = 73.6–77.6 wt.%, A/CNK ratios of 1.0–1.6, and CIPW normative corundum contents of 0.7–5.3 wt.%. They are enriched in LREEs, LILEs (e.g., Rb, Th, U, and K) and Pb, and depleted in HFSEs (e.g., Nb, Ta, P, Zr, and Ti), Eu, Sr, and Ba. The $\varepsilon_{Hf}(t)$ values for co-magmatic zircons of the Shuangmaidi coarse- and fine-grained porphyritic granites show wide ranges from −11.6 to +5.2 and from −8.1 to +7.0, concentrating in −7.1 to +0.5 and −8.1 to +0.7, respectively; and those of the Mengmao granites concentrate between −4.6 and −0.5. The primary magmas of these granites can be mainly attributed to the partial melting of ancient metasedimentary rocks, while small amounts of mantle-derived components were introduced into the magma sources for the Shuangmaidi granites. The primary magma of the Shuangmaidi granites experienced biotite-dominant mineral fractionation, and that of the Mengmao granite mainly fractionated K-feldspar and plagioclase. Combining our data with the regional sedimentary unconformity, multi-type magmatism, and high-pressure metamorphism in the Baoshan and its periphery blocks, we propose that these ca. 470–460 Ma peraluminous granites were formed in the tectonic setting of the thickened lithospheric delamination following the final amalgamation of outboard Asian microcontinents onto the East Gondwana margin at ca. 490–475 Ma. Our study favors that the long-lasted (ca. 500–450 Ma) peraluminous granitic rocks in the Baoshan block constitute of the early Paleozoic magmatic belt along the East Gondwana marginal blocks like Himalaya, Lhasa, and Qiangtang. This magmatism was produced in successive stages, including proto-Tethyan slab rollback period to ca. 500 Ma, slab break-off at ca. 500–490 Ma, lithospheric thickening at ca. 490–475 Ma, and lithospheric delamination at ca. 475–460 Ma; and then it vanished at ca. 450 Ma signifying the end of proto-Tethyan accretionary orogenesis.

1. Introduction

The mainland of Southeast Asia is an amalgamation of allochthonous continental blocks and volcanic arcs, separated by a series of Tethyan sutures (Fig. 1a). These blocks were derived from the India–Australian margin of East Gondwana and successively accreted to Eurasia during the Paleozoic and Mesozoic (e.g., Cocks and Torsvik, 2013; Metcalfe, 2006, 2011; G.T. Pan et al., 2012). The late Precambrian to earliest Paleozoic was a crucial period that marks the final assembly of the Gondwana supercontinent and the initial slab subduction along the peri-Gondwana margin (e.g., Cawood and Buchan, 2007; Collins and Pisarevsky, 2005; Meert, 2003; Murphy et al., 2011). Recent geochronological studies have demonstrated that the early Paleozoic (ca. 540–450 Ma) magmatic rocks are ubiquitous in the East Gondwana marginal blocks including Lhasa, Amdo, Himalaya, South Qiangtang, and Sibumasu (Fig. 1) (e.g., Ding et al., 2015; Hu et al., 2015). The petrogenesis of the early Paleozoic rocks, however, is still in debate. Most works suggested that these early Paleozoic magmatic rocks were the result of subduction of proto-Tethyan oceanic slab beneath Gondwana (e.g., Cawood et al., 2007; DeCelles et al., 2004; Ding et al., 2015; Hu et al., 2013; Liu et al., 2009; X.X. Wang et al., 2012; Y.J. Wang et al., 2013; Z.M. Zhang et al., 2012) and the subsequent collisional accretion of outboard Asian microcontinents onto the supercontinent

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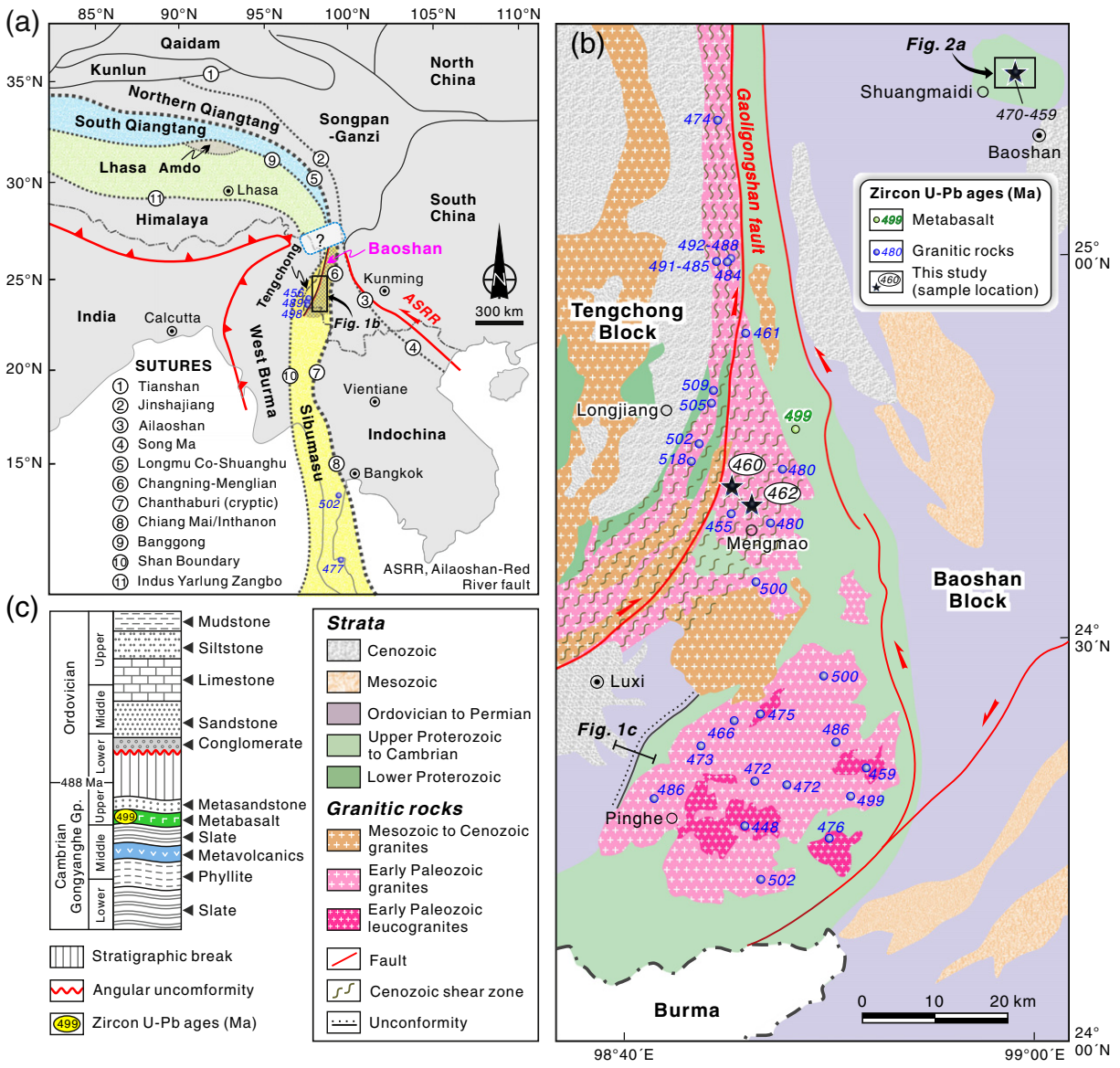

Fig. 1. (a) Tectonic subdivision of mainland Southeast Asia. (b) Simplified geological map of the western Baoshan block showing the sample locations of this study. The ages for early Paleozoic granitic rocks in the Sibumasu block are shown in blue circles and that for metabasalt in green one. (c) Cambrian–Ordovician stratigraphic section, southwestern Baoshan block. (a) Modified after Metcalfe (2013) and Zhu et al. (2013). (b) Modified after Cai et al. (2013) and Deng et al. (2014b). Data sources: Baoshan block (Chen et al., 2007; Dong et al., 2012, 2013a; Liu et al., 2009, 2012; Y.J. Wang et al., 2013; Xiong et al., 2012; Yang et al., 2012), Tengchong block (Cai et al., 2013; Cong et al., 2009; Li et al., 2012; Lin et al., 2012; Liu et al., 2012; Song et al., 2007; Y.J. Wang et al., 2013), Southern part of Sibumasu block (~502 Ma Khao Tao orthogneiss from Lin et al. (2013) and ~477 Ma Khao Dat Fa granite from Kawakami et al. (2014)). (c) Revised from Cai et al. (2013) and Yang et al. (2012).

(e.g., Cawood et al., 2007; Hu et al., 2015; Zhu et al., 2012). However, other studies proposed that these magmatic rocks were formed in a post-collision extensional setting in response to the final assembly of Gondwana (e.g., Miller et al., 2001; Murphy and Nance, 1991; X.P. Pan et al., 2012; Song et al., 2007; Xu et al., 2005, 2014).

The Baoshan block, the northern tip of the Sibumasu block, is an integral component of East Gondwana until the opening of the Meso-Tethys Ocean in early Permian (e.g., Cocks and Torsvik, 2013; Metcalfe, 2011; Ueno, 2003; Wang et al., 2014). Numerous early Paleozoic peraluminous granitic rocks are emplaced continuously from ca. 502 Ma to 448 Ma in the Baoshan block (Fig. 1b) (Chen et al., 2007; Dong et al., 2012, 2013a; Liu et al., 2009, 2012; Y.J. Wang et al., 2013; Xiong et al., 2012). Even within the hypothesis of proto-Tethyan slab subduction, the geodynamic drive for this extensively long-lived magmatism is still not in consensus. One group of scholars considered that the granites before ca. 490 Ma were produced by oceanic slab subduction, and those after ca. 490 Ma by the subsequent post-collisional extension after the collisional accretion of outboard Asian microcontinents (Dong et al., 2013a; Liu et al., 2009). The opposite opinion stated that the granites emplaced from ca. 500 Ma to 460 Ma were all the products of ongoing slab subduction of proto-Tethyan Ocean (Y.J. Wang et al., 2013). One crucial factor leading to this disagreement is how to explain the genesis of granitic rocks with peraluminous features that have been documented in various tectonic settings (e.g., Barbarin, 1996; Clemens, 2003; Collins and Richards, 2008; Sylvester, 1998).

In this study, we focused on the petrogenesis of the Shuangmaidi and Mengmao peraluminous granites emplaced at 470–459 Ma from the Baoshan block, and elucidated their tectonic model in the context of a systematic review on the regional magmatic, sedimentary, and metamorphic records. Accordingly, a favored geodynamic evolution is brought forward for the generation of the long-lasting early Paleozoic peraluminous magmatism in the Baoshan block.