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Discovery of Hadean–Mesoarchean crustal materials in the northern Sibumasu block and its significance for Gondwana reconstruction

Gongjian Li, Qingfei Wang*, Yuhan Huang, Fuchuan Chen, Peng Dong

State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing 100083, China

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ABSTRACT

The micro-continental blocks in SE Asia are thought to be derived from the East Gondwana which has a basement as old as Hadean–Mesoarchean. However, such old crustal materials have not been found anywhere in SE Asia. In this paper, we report the occurrence of the Hadean–Mesoarchean crustal materials in the northern Sibumasu block, SW China. Our finding is based on inherited zircon U–Pb ages and Hf isotope model ages of co-magmatic zircon crystals from early-Paleozoic S-type granitoids in the northernmost Sibumasu. LA-ICP-MS zircon U–Pb isotopic analysis reveals that some S-type granitoids in this region formed between 468 Ma and 447 Ma. These rocks are strongly peraluminous, with high A/CNK ratios > 1.2 and normative corundum content >2 wt%, and have low CaO/Na_2O ratios <0.3, which indicates that they formed by anatexis of metapelitic crustal rocks. The ca. 470–450 Ma S-type granitoids contain inherited zircon crystals as old as Mesoarchean (~3.1 Ga). The $\varepsilon_{Hf}(t)$ values of zircon crystallized from the magmas of these rocks vary from −49 to +16, with major peaks approximately at −46, −35 and −27. The corresponding model ages for the formation of the source crust are ~4.39 Ga, ~3.62 Ga and ~3.12 Ga. This, together with the discovery of ~3.1 Ga inherited zircon in the granitoids, indicates that the northern Sibumasu block has Hadean–Mesoarchean crustal materials. A Gondwana-wide comparison of crustal formation time data reveals that these Hadean–Mesoarchean crustal materials show similar age distribution with the crusts of the Pilbara and Yilgarn Cratons, Western Australia. Their derivation analysis provides a new line of evidence for the majority view that the Sibumasu block was attached to NW Australia before its breakup from Gondwana.

1. Introduction

The mainland SE Asia is a collage of micro-continental blocks, volcanic arcs, and suture zones that contain the remnants of the Tethyan Oceans. These continental blocks rifted from East Gondwana and subsequently accreted to the Eurasia in the Paleozoic and Mesozoic (e.g., Metcalfe, 2006, 2011; Cocks and Torsvik, 2013). Tracing the origin of individual micro-continental block in SE Asia is important in Gondwana reconstruction (e.g., Cawood and Buchan, 2007; Metcalfe, 2013).

The Sibumasu block is one of the largest continental blocks in SE Asia (Fig. 1a). Cocks and Torsvik (2002) suggested that this block was separated from the rest of East Gondwana in the early Paleozoic. More recently, these authors (Torsvik and Cocks, 2009; Cocks and Torsvik, 2013) and many other researchers (e.g., Ueno, 2003; Metcalfe, 2006, 2013; Ferrari et al., 2008) proposed that the Sibumasu block was an integral constituent of East Gondwana until the opening of the Meotethys Ocean in the Early Permian. Despite decades of deliberation based on results from multi-disciplinary studies such as paleomagnetics (Ali et al., 2013; Xu et al., 2015), faunal/floral distribution (Burrett et al., 1990; X.D. Wang et al., 2013; Metcalfe and Aung, 2014), tectonostratigraphy (Stauffer and Lee, 1989; Ampaiwan et al., 2009), zircon age-dating of crustal basement (Guynn et al., 2012), paleoenvironmental reconstruction (Waterhouse, 1982; Dopieralska et al., 2012) and detrital zircon provenance (Burrett et al., 2014; Cai et al., 2015), the exact location of the Sibumasu block in the East Gondwana before its breakup in early Paleozoic remains controversial (see summary in Ali et al., 2013).

Crustal evolution studies have witnessed increased interest in the recent years on the vestiges of extremely old crustal components preserved in the Gondwana-derived continents (e.g., Harrison et al., 2005, 2008; Nelson, 2008; Jayananda et al., 2013; Van Kranendonk et al., 2013). A number of recent reports on Hadean

* Corresponding author at: State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, No. 29, Xueyuan Road, Beijing 100083, China. Tel.: +86 10 82322301; fax: +86 10 82322301.
E-mail address: wqf@cugb.edu.cn (Q. Wang).

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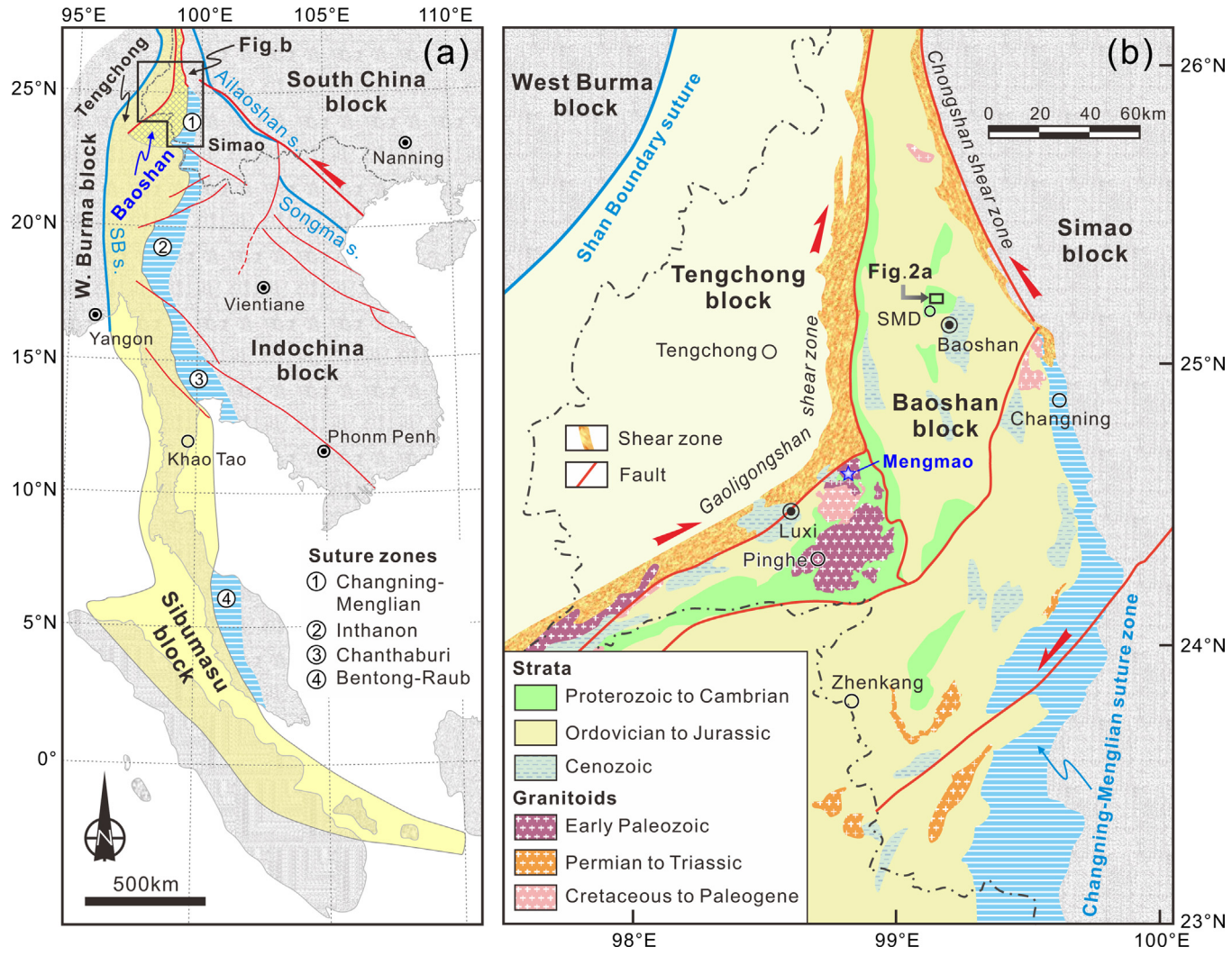

Fig. 1. (a) Distribution of the principal continental blocks and suture zones of mainland SE Asia emphasizing the lineament of Sibumasu in which the Baoshan block is located (modified after Sone and Metcalfe, 2008). (b) Simplified geological map showing the regional tectonic relationships of the Baoshan, Tengchong and Simao blocks, and the distribution of the major strata, igneous rocks and faults in the Baoshan block (modified after Burchfiel and Chen, 2012; Deng et al., 2014a,b; Li et al., 2015a).

materials from mircoblocks in the western Australia and southern India, which are important constituents of the Gondwana, have presented in the literature (e.g., Wilde et al., 2001; Harrison et al., 2005, 2008; Tessalina et al., 2010; Santosh et al., 2014). This arouses our interest to look for ancient crustal material, especially the Hadean record, which has not been found anywhere in SE Asia (Metcalfe, 2013; Deng et al., 2014a), in the Sibumasu block. In this study, we use samples from S-type granitoids in northmost Sibumasu that formed by crustal anataxis and contain both inherited and co-magmatic zircon crystals. The U–Pb ages and Hf isotopes of these two types of zircon together are used to determine the nature of the source crust (e.g., Horie et al., 2010; Qiao et al., 2015). This approach has proven to be a powerful tool to study the origin and evolution of the Earth's crust (e.g., Harrison et al., 2005; Kemp et al., 2010). The results provided the first evidence for the occurrence of Hadean–Mesoarchean crust material in Sibumasu, which is further utilized to locate the Sibumasu block in the East Gondwana before its breakup in early Permian.

2. Geological background and samples

The Sibumasu continental block is an elongated belt stretching from southwestern Yunnan in the north, through Thailand in the middle, to Sumatra in the south (Fig. 1a) (e.g., Ueno, 2003; Metcalfe, 2011). It is widely accepted that the Sibumasu block is a Gondwana-derived continental fragment (e.g., Metcalfe, 2006, 2013; Ampaiwan et al., 2009; Ridd, 2009; Ali et al., 2013; Burrett et al., 2014). It was separated from Gondwana in Early Permian and accreted to Indochina after the Paleotethys Ocean was closed in the Middle–Late Triassic (Sone and Metcalfe, 2008).

The Baoshan block is the northern tip of the Sibumasu block (e.g., Metcalfe, 2011; Burchfiel and Chen, 2012). It is separated from the Simao block by the Changning-Menglian Paleotethys suture zone to the east and from the Tengchong block by the Gaoligongshan shear zone to the west (Fig. 1b; Burchfiel and Chen, 2012; Deng et al., 2014a). The Baoshan block consists of an outcropped Late Neoproterozoic to Cambrian basement which is mainly composed of low-grade metamorphosed siliciclastic and carbonate rocks, locally intercalated with volcanic rocks in the upper part (BGMRY, 1990; Yang et al., 2012), and a Paleozoic to Mesozoic sedimentary cover which is mainly composed of carbonates and clastic rocks, with minor Early Permian volcanic rocks (Burchfiel and Chen, 2012). The meta-basalt from the basement yields zircon U–Pb age of ~499 Ma (Yang et al., 2012). Early Paleozoic and Late Cretaceous to Paleocene granitoids are the main magmatic rocks present in the Baoshan block (Fig. 1b; e.g., Dong et al., 2013a,b; Li et al., 2015b). The early