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Early Neoproterozoic (~840 Ma) arc magmatism: Geochronological and geochemical constraints on the metabasites in the Central Jiangnan Orogen

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ABSTRACT

The Jiangnan Orogen is traditionally considered the suture zone, along which the Yangtze and Cathaysia blocks collided to form the united South China Block. There are still major controversies surrounding the pre-collisional tectonic pattern and amalgamation process along the Orogen and the relationship of the united South China Block (SCB) with the Rodinia. Our recent field investigations identified the presence of the volcano-sedimentary unit of the Lengjiaxi Group at Jianxichong, with the thickness of over 1700 m. A set of new zircon U–Pb geochronological, whole-rock elemental and Sr–Nd isotopic data for the metabasites have been obtained and presented in this paper. The layered diabase and tuffaceous samples from the Jianxichong volcano-sedimentary unit yielded the weighted mean ages of 837 ± 5 Ma and 835 ± 6 Ma, respectively. The U–Pb ages of detrital zircons from the phyllite interlayer form a main age-cluster at the peak age of 870 Ma with the youngest apparent age of 845 ± 23 Ma. This indicates that the metabasites in the Jianxichong volcano-sedimentary unit formed at ~845–835 Ma rather than in the previously-thought Neoarchean in the Central Jiangnan Orogen. The metabasitic samples have SiO_2 ranging from 48.78 wt.% to 53.72 wt.% and MgO from 7.71 wt.% to 12.74 wt.% with mg-number of 63–71, and hence can be classified as tholeiitic basalt and basaltic andesite. They demonstrate a sub-parallel and right-sloping chondrite-normalized REE pattern with slightly negative Eu anomalies and sub-parallel spiky PM-normalized patterns with enrichment in LILEs, depletion in HFSEs and P–Ti negative anomalies, similar to those of arc volcanic rocks. Their $\varepsilon_{Nd}(t)$ values range from −1.64 to −0.37 and initial $^{87}Sr/^{86}Sr$ values from 0.7046 to 0.7081, respectively. Such crust-like geochemical characteristics might have been inherited from a sub-arc source modified by fluid/melt released from the subduction sedimentary component. In conjunction with available data and geological observations, we herein propose the development of the early Neoproterozoic (~840 Ma) continental arc-basin system along the Central Jiangnan Orogen in response to an arc-continent accretionary assembly along the Rodinia exterior.

1. Introduction

The assemblage of the Yangtze with Cathaysia Blocks created the SCB along the Jiangnan Orogen during the Neoproterozoic period (e.g., Charvet et al., 1996; Li et al., 2002, 2008, 2009; Wang et al., 2006, 2013a, 2014; Yu et al., 2012; Zhang and Zheng, 2013; Zhang et al., 2012a, 2013a, 2015; Yao et al., 2014, 2015; Zhao, 2015). The Shaoxing-Jiangshan fault has been widely accepted as the suture in the Eastern Jiangnan Orogenic zone due to the preservation of oceanic remnants, arc igneous rocks and related geological signatures (e.g., Li et al., 2002, 2008, 2009; Wang et al., 2006, 2007a; Ye et al., 2007; Zhang et al., 2012b). Numerous studies have been done on the Neoproterozoic igneous and sedimentary rocks along the Central (NW Jiangxi and NE Hunan Provinces) and Western (western Hunan and northern Guangxi Provinces) Jiangnan Orogen (Fig. 1a; Gan et al., 1996; Li, 1997; Wang et al., 2004, 2007b; Zhou et al., 2004, 2009; Zheng et al., 2006, 2007, 2008; Zhao et al., 2011; Zhang et al., 2013a, 2015).

Main attention has been paid to the Neoproterozoic (830–750 Ma) igneous rocks along the Central and Western Jiangnan Orogen, for example, the <830 Ma mafic–ultramafic rocks that are traditionally considered the oceanic remnants (e.g., Wang

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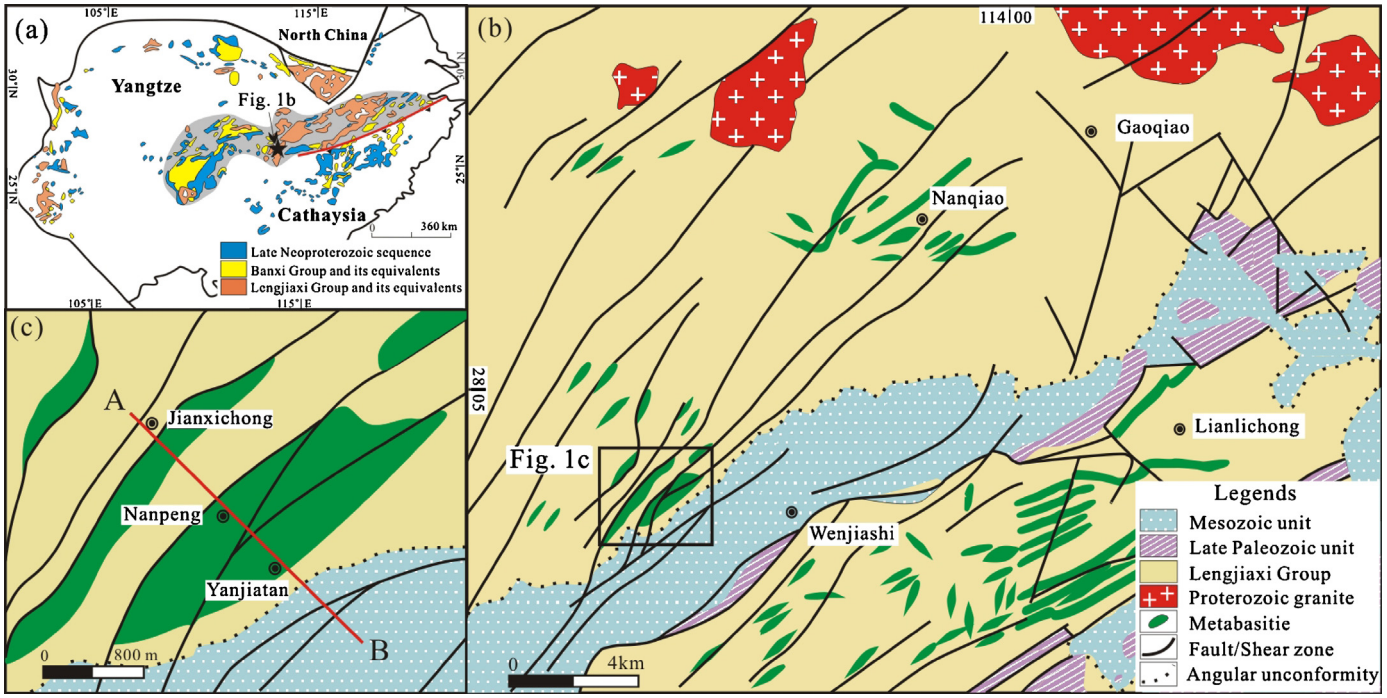

Fig. 1. Simplified geological maps of (a) the Precambrian basement of the Yangtze and Cathaysia Blocks separated by the Jiangnan Orogen (Zhang et al., 2012a), (b) the Wenjiashi region (modified after Hunan BGMR, 1988), and (c) the Jianxichong region showing the location of a cross section A–B in Liuyang, Hunan.

et al., 2004, 2006, 2012a, 2012b; Zhou et al., 2009; Zhao et al., 2011). In contrast, >830 Ma igneous rocks, especially mafic rocks, have been poorly reported along the Jiangnan Orogenic belt. Zhang et al. (2013a) reported 860–838 Ma basalts and dolerites generated in a back-arc or fore-arc basin setting in the Wenjiashi-Fangxi areas along the Central Jiangnan Orogen. Yao et al. (2014) identified ~850 Ma arc-related magmatic rocks in northern Guangxi along the western Jiangnan Orogen. In general, the pre-collisional tectonic pattern and initial collisional timing for the Central Jiangnan Orogen are still in dispute and remain unsolved. This leads to further controversies over the amalgamation process along the Jiangnan Orogen. For example, some researchers considered that the amalgamation of the SCB along the Jiangnan Orogen occurred at 1.0–0.9 Ga (named "Sibao orogeny"), equivalent with the global Grenvillian orogeny, and the subsequent (~830–750 Ma) rifting geodynamically related to the mantle plume or superplume in response to the breakup of the supercontinent Rodinia (e.g., Li et al., 1995, 1999, 2003, 2009; Greentree et al., 2006; Wang et al., 2007a; Ye et al., 2007). Other researchers believed that the SCB was created by the oceanic subduction and subsequent arc/continental–continental collision at ~1.0–0.8 Ma along the periphery of Rodinia (e.g., Zhou et al., 2002, 2009; Wang et al., 2004, 2013a, 2014; Zheng et al., 2006, 2007, 2008; Zhao et al., 2011; Zhao and Cawood, 2012; Zhang et al., 2012a, 2013a, 2015; Cawood et al., 2013).

The Jiangnan Orogen is accepted to be an important tectonic boundary between the Yangtze and Cathaysia Blocks (e.g., Shu and Charvet, 1996; Li et al., 1999; Zhao and Cawood, 2012; Zhang et al., 2012a, 2013a, 2015 and reference therein). It extends along the NE-trending with a length of >1000 km and a width of 80–120 km (Fig. 1a; e.g., Jiangxi BGMR, 1984; Hunan BGMR, 1988). Along this Orogen, there exposed abundant Neoproterozoic sequences involving the Lengjiaxi Group and Banxi Group as well as their equivalents, along with small amount of the Neoproterozoic igneous rocks, especially mafic–ultramafic rocks (e.g., Jiangxi BGMR, 1984; Hunan BGMR, 1988; Zhang et al., 2012a, 2013a). These Neoproterozoic mafic and ultramafic rocks are critical to understanding the tectonic evolution of the SCB and its relationship with Rodinia supercontinent. It is especial that the mafic rocks with the formation ages of >830 Ma along the Central Jiangnan Orogen play a key role in better unraveling the pre-collisional tectonic setting and testing various different tectonic models of the SCB. Our recent field investigations identified the metamorphic volcano-sedimentary unit in the Lengjiaxi Group with the thickness of over 1700 m at the Jianxichong area (named herein the Jianxichong unit), Liuyang (Hunan Province, China). The unit is characterized by metabasites, sandstone, phyllite and tuffaceous rocks, as shown in Fig. 2. In this paper, we document field observation, zircon U–Pb geochronological, whole-rock elemental and Sr–Nd isotopic data for the metabasites, along with zircon U–Pb geochronological data for the tuff and phyllite from the Jianxichong unit in the Central Jiangnan Orogen. Our data reveal the development of an early Neoproterozoic (~840 Ma) arc environment along the Central Jiangnan Orogen of the SCB arc-continent accretionary regime along the exterior Rodinia.

2. Geological background and petrology

The outcropped strata along the Jiangnan Orogen include the Neoproterozoic sequence, Paleozoic shallow marine package and Mesozoic terrestrial sequence (e.g., Hunan BGMR, 1988; Wang et al., 2005; Dong et al., 2014; Li et al., 2014). The Paleozoic package is composed of Cambrian slaty shale, sandstone and limestone, Ordovician limestone and argillaceous siltstone, Silurian shale and sandstone, Middle and Upper Devonian sandstone and siltstone, Carboniferous and Permian limestone, and Lower Triassic carbonatite. The upper Paleozoic Devonian–Lower Triassic sedimentary sequence is angular unconformably underlain by the lower Paleozoic Cambrian-Silurian sequence, and overlain by the Upper Triassic–Cretaceous terrestrial siliciclastic strata.

The Neoproterozoic sequence in the Jiangnan Orogen comprises the Lengjiaxi, and Banxi Groups, as well as their equivalents, along with the Sinian tillite and limestone (e.g., Jiangxi BGMR, 1984; Hunan BGMR, 1988; Zhang et al., 2012a, 2013a). The