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Depositional age, provenance characteristics and tectonic setting of the Meso- and Neoproterozoic sequences in SE Yangtze Block, China: Implications on Proterozoic supercontinent reconstructions

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ABSTRACT

Meso- to Neoproterozoic sedimentary successions along the southeastern margin of the Yangtze Block in South China have been investigated for their depositional ages, provenance and tectonic setting. The 1524 Ma, 834 Ma and 763 Ma U-Pb ages of detrital zircons for here investigated Tianli Schists, Liuyuan and Wengjialing sandstone constrain the maximum depositional ages for the respective sedimentary protoliths. Considerable time lag between onset of sedimentation and the age of source rocks suggests that the sedimentary protolith of the Tianli Schists received detritus from a wide range of cratonic sources in a tectonically passive scenario, as indicated by their elevated Zr/Sc ratios. Extraneous source for the 2700–2600 Ma detritus indicates that the sedimentary protolith for the Tianli Schists itself was deposited in a basin that received detritus from the Yangtze Block during the fragmentation of the Columbia/Nuna supercontinent. On the other hand, profuse syn-sedimentary magmatic (804–849 Ma) detritus for the Liuyuan sandstone indicates a continental arc setting, also supported by the La-Th-Sc and Th-Co-Zr signatures. The Wengjialing Formation and its equivalents were deposited in a continental rift basin, coeval with the breakup of Rodinia supercontinent, with addition of newly formed arc-related rocks (≥820 Ma) and syn-rifting magmatic rocks (810–760 Ma) as the predominant sources. These features provide substantial evidence for the paleogoegraphic reconstructions of the southeastern Yangtze Block within the Proterozoic supercontinent configurations.

1. Introduction

Studies on paleogeographic reconstructions during Earth's early history have linked supercontinent amalgamation cycles with juvenile crustal addition, reworking and changes in the atmospheric oxygen levels (Hoffman, 1991; Moores, 1991; Rogers and Santosh, 2002; Zhao et al., 2002; Campbell and Allen, 2008; Cawood et al., 2013a). Two supercontinents, the ~2.0–1.5 Ga Columbia/Nuna and ~1.3–0.75 Ga Rodinia, have been postulated during Proterozoic and almost all the present day continents have been thought to be involved in their assembly and breakup (Rogers and Santosh, 2002; Zhao et al., 2002; Meert, 2002). However, the position and role of some continental blocks, such as the Yangtze Block in South China in Columbia and Rodinia supercontinents continue to be debated on account of being ambiguous and loosely constrained (Zhou et al., 2002a; Zheng, 2004; Li et al., 2008c; Peng et al., 2012; Cawood et al., 2013b; Belica et al., 2014; Wang et al., 2016; Cawood et al., 2017). Contentious and diverse interpretations on widespread Neoproterozoic magmatism and sedimentation in the Yangtze Block, south China, have led to a range of its proposed linkages with Rodinia supercontinent (Li et al., 2003; Zhou et al., 2008; Zhao et al., 2011; Cawood et al., 2013b; Zhao and Zheng, 2013). Paleo- and Mesoproterozoic rocks that could provide vital information about paleoposition of the Yangtze Block in Columbia supercontinent were rarely investigated in previous studies, probably on account of paucity of exposures (Zhang et al., 2006b; Yin et al., 2013a; Wang and Zhou, 2014). In combination with the widely distributed Neoproterozoic rocks, these older rocks are crucial in ascertaining the paleoposition and role of the Yangtze Block in Columbia to Rodinia supercontinent cycles.

As one of these scantily exposed Mesoproterozoic successions in the

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southeastern Yangtze Block, the Tianli Schists could be an important window to provide insight into the tectonic evolution of the Yangtze Block during the breakup of Columbia and assembly of Rodinia supercontinents (Li et al., 2007). The Tianli Schists are unconformably overlain by the Neoproterozoic sedimentary sequences (Wengjialing and Liu Formations) along a faulted contact, both providing an ideal opportunity to study the evolution of sedimentary basins and regional tectonic. Geochronological characterization of the Tianli Schists is poorly constrained on account of metamorphism and strong deformation (Fan et al., 1997; Li et al., 2007). However, the bimodal volcanics from the overlying Shangshu (also known as the Taoyuan) Formation have been well constrained at 803 ± 9 Ma, ascribed to mark the onset of continental rifting in the Yangtze Block and sedimentation in the Nanhua rift basin in the Jiangnan sub-basin (Li et al., 2008b,d; Wang et al., 2015). Metamorphism and deformation may have overprinted and modified the bulk chemistry and obliterated primary sedimentary structures, therefore a cautionary approach using refractory minerals, like zircon and immobile elements such as Ti, Th, Sc and REE, can be employed for inferring the provenance and sedimentary dispersal systems, thus the tectonic setting of sedimentary basins (Bhatia and Crook, 1986; Fedo et al., 2003; Sun et al., 2008; Liu et al., 2014b; Nulay et al., 2016). In this study we present zircon U-Pb age data and bulk rock geochemistry of meta-sedimentary rocks from the Tianli Schists and overlying Neoproterozoic sequences in order to understand the age, provenance and tectonic setting of the sedimentary protoliths of these rocks. The findings are discussed in terms of basin evolution and its linkage with Columbia and Rodinia supercontinents.

2. Geological background of the Yangtze Block, South China

The South China Block consists of Yangtze Block in the northwest and the Cathaysia Block in the southeast with the Neoproterozoic Jiangnan Orogen/Fold Belt situated at the southeastern margin, however, the petrogenesis and tectonic setting of these Neoproterozoic rocks continue to be debated (Fig. 1) (Li et al., 2009; Zhao and Cawood, 2012; Charvet, 2013; Zheng et al., 2013; Zhou et al., 2014; Wang et al., 2014c; Yao et al., 2015; Zhao, 2015; Gao et al., 2016; Cui et al., 2017; Xia et al., 2017). Compared to the widespread Neoproterozoic igneous and sedimentary rocks, Mesoproterozoic to Archean rocks are rarely exposed in both the Yangtze and Cathaysia blocks (Li et al., 2008a; Yu et al., 2010; Zhao et al., 2010, 2011; Qiu et al., 2011; Wu et al., 2012; Wang et al., 2013b, 2014b, 2016; Chen et al., 2014, 2017; Han et al., 2017a,b). Previously thought to be Mesoproterozoic in age, the Jiangnan Fold Belt has been confirmed as a Neoproterozoic sequence (Zhao et al., 2011; Zhang et al., 2012a; Wang et al., 2012a,b,c; Yao et al., 2014), demonstrating strong overprint on the Pre-Neoproterozoic rocks in the southeastern Yangtze Block. The Pre-Neoproterozoic rocks in the southeastern Yangtze Block are represented by the Tianli Schists and the 1159 ± 8 Ma Tieshajie volcanic rocks (Li et al., 2007, 2013a,b). The sedimentary cover of the Yangtze Block consists mainly of folded Paleozoic and Lower Mesozoic, shallow marine sedimentary deposits (Yan et al., 2003) that are strongly deformed along the Mesozoic intracontinental Xuefengshan Belt (Chu et al., 2012a,b). In contrast, there are no exposed Archean rocks in the Cathaysia Block. The oldest exposed rocks in the region are Paleoproterozoic (1890–1830 Ma) granitoids and the Badu Complex, the latter sporadically cropping out in the northeastern part of the Cathaysia Block (Yu et al., 2009, 2012; Xia et al., 2012; Liu et al., 2014c; Zhao et al., 2014). Mesoproterozoic rocks in the Cathaysia Block are restricted to the Hainan Island, where they include turbidites and volcaniclastic rocks of the Baoban Group (ca. 1.43 Ga) and meta-sedimentary rocks and iron formations of the Shilu Group (ca. 1.44 Ga) (Xu et al., 2007; Li et al., 2008). Neoproterozoic rocks are the dominant Precambrian units in the Cathaysia Block, represented by the Mamianshan, Mayuan and Louziba Groups in the Wuyishan area, the Chencai and Longquan Groups in the Chencai-Badu area, and the Yunkai Group in the Yunkai area (Wan et al., 2007; Li et al., 2010; Shu et al., 2011; Wang et al., 2013a,b).

2.1. The Tianli Schists and overlying Neoproterozoic sequence

With a ca. 15 km^2 outcrop area along the eastern segment of the Jiangnan Fold Belt (Figs. 1 and 2), the Tianli Schists predominantly consists of quartz mica schist and calcareous mica schist with minor quartzite and marble and several meter thick, medium- to coarse-grained sandstone (Fig. 3a and b). The Tianli Schists are bounded by Neoproterozoic to Phanerozoic strata along a faulted contact. Also, high-angle unconformable contact between the Tianli Schists and Neoproterozoic Wengjialing Formation is observed along the southeastern margin of the outcrop. The sedimentary rocks have been metamorphosed up to middle and upper greenschist facies. Primary sedimentary bedding has been almost entirely transposed by foliations and mylonitization (Fig. 3a and b) and development of occasional meter-scale isoclinal folds. In sharp contrast, the overlying Neoproterozoic successions, known as the Liuyuan, Wengjialing, Shangshu and Tingmeng formations, experienced relatively low-grade metamorphism and less intense deformation. With thickly bedded to massive quartz sandstones at the base, the Liuyuan Formation contains tuffaceous siltstone and gravel-bearing sandstone in its middle and upper parts (Wang et al., 2015) (Fig. 3c). The Wengjialing Formation consists of a basal conglomerate unit with near-sourced, variable-sized volcanic clasts and reddish sandstone (Fig. 3d). The Shangshu Formation is mainly composed of lava flows and pyroclastic rocks, recently dated at 803 ± 9 (Wang et al., 2015), revising the previously reported 827 ± 14 Ma age by Li et al. (2008b,d). The Tingmeng Formation consists of a basal conglomerate and gravel-bearing feldspathic lithic sandstones.

The Tianli calcareous mica schists are composed of muscovite, quartz and calcite (Fig. 4a), whereas Tianli quartz mica schists mainly contain quartz that is strongly flattened parallel to the schistosity (Fig. 4b). Metamorphic muscovite laths also define the schistosity. Lithic fragments and variably recrystallized quartz are the major detrital components of the Liuyuan sandstone (Fig. 4c). Relatively higher abundance of plagioclase and K-feldspar is the distinctive feature of Wengjialing Formation sandstone and lithic fragments are mainly composed of metamorphic rocks (Fig. 4d). Detrital grains in these sandstones are angular to subangular and poorly sorted (Fig. 4d).

3. Sampling and analytical methods

The Tianli Schists was sampled at the type locality around the Tianli village and at Shaorao City, Jiangxi Province, southeastern Yangtze Block (Figs. 1 and 2). A total of 18 meta-sedimentary rock samples comprising four calcareous mica schist and five quartz mica schist samples from the Tianli Schists, four Liuyuan sandstone samples and five sandstone samples from the Wengjialing Formation (Table 1), were collected from sections documented in the literature and examined during the field work. All the samples were cleaned in deionized water before being crushed with steel jaw crusher, and then powdered using an aluminum oxide mill. All samples were measured for bulk-rock major and trace elements. Zircons were separated from four samples TLW1105, TLW1115, TLW1132 and TLW1136 for U-Pb dating. Among these, nine samples, including four samples of the Tianli Schists, three of Liuyuan sandstone and two of Wengjialing sandstones, were further subjected to whole rock Sm-Nd isotope analysis.

3.1. Bulk rock major and trace elements

Major-element abundances were measured on fused glass beads using X-ray fluorescence (XRF) spectrophotometry at the University of Hong Kong. Trace elements were analyzed on a Quadrupole ICP-MS at the State Key Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang. To ensure