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The Precambrian tectonic evolution of the western Jiangnan Orogen and western Cathaysia Block: Evidence from detrital zircon age spectra and geochemistry of clastic rocks

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ABSTRACT

The Jiangnan Orogen and Cathaysia Block constitute integral components in the geological framework of the South China Craton. However, the tectonic attributes of these two regions remain controversial. In this study we present LA–ICP–MS zircon U–Pb ages, Lu–Hf isotopes, and major and trace elements data from a suite of clastic rocks. Two hundred and forty seven zircon U–Pb ages obtained from the Neoproterozoic meta-sandstones in western Jiangnan Orogen define three major age populations: 2564–2395 Ma, 2068–1849 Ma and 963–730 Ma, corresponding to the early Paleoproterozoic crustal growth, amalgamation of the supercontinent Columbia and tectonics associated with Rodinia. Two hundred and forty three zircon U–Pb age data from Cambrian and Ordovician sandstones in the western Cathaysia yield five age populations: 2626–2392 Ma, 2050–1518 Ma, 1173–904 Ma, 857–708 Ma and 630–502 Ma, which can be correlated to the Neoarchean–early Paleoproterozoic continental growth, the tectono-thermal events associated with the Columbia supercontinent, the assembly and breakup of Rodinia, as well as the Pan-African event. The 630–502 Ma population correlates with the assembly of Gondwana supercontinent during late Neoproterozoic to early Paleozoic, although direct geological evidence for this event has not yet been reported from this region. These results suggest that the western Jiangnan belt and western Cathaysia Block have distinct crustal evolution histories albeit with close affinities. The REE geochemistry and Lu–Hf isotope data also indicate that the provenances of the Neoproterozoic and early Paleozoic detritus in western Jiangnan belt and western Cathaysia are mostly composed of reworked crustal materials. The metamorphic rims of zircon grains with core–rim structures yield ages of 912–891 Ma and 853–835 Ma, suggesting two phases of metamorphic events during Neoproterozoic in the source areas. These two events are likely associated with the tectonics related to the collision of Yangtze and Cathaysia blocks in the western and eastern segments, respectively.

1. Introduction

The South China Craton is composed of two distinct tectonic domains: the Yangtze and Cathaysia Blocks (referred as "Cathaysia Oldland" (Grabau, 1924)) (Fig. 1). The Jiangnan Orogen, marking the Neoproterozoic northeast–trending collisional suture of the Cathaysia Block with the Yangtze Block, is located at the southeastern margin of the Yangtze Block and separated from the Cathaysia Block to the southeast by the Shaoxing–Jiangshan–Piangxiang–Shuangpai fault zone (Shu, 2012; Shu et al., 2011; Wang et al., 2006, 2007a; Yao et al., 2012, 2014a,b; Zhao, 2015; Zhao and Cawood, 2012). Over the past decade, advancements in research on the Jiangnan Orogen and Cathaysia Block led to the proposal of new tectonic models which also led to new controversies surrounding the evolution of these two regions, as well as the timing of the collision of the Yangtze and Cathaysia Blocks (e.g. Charvet, 2013; Li et al., 2007, 2008, 2012; Shu, 2006, 2012; Shu et al., 2008a, 2011, 2014; Yao et al., 2012, 2013a, 2014a,b; Zhao, 2015). Shu (2012) and Shu et al. (2004, 2008a) suggested that the Jiangnan Orogen and the Cathaysia Block have distinct Precambrian basements, and had different paleogeographic setting due to rifting since the early Nanhua period.

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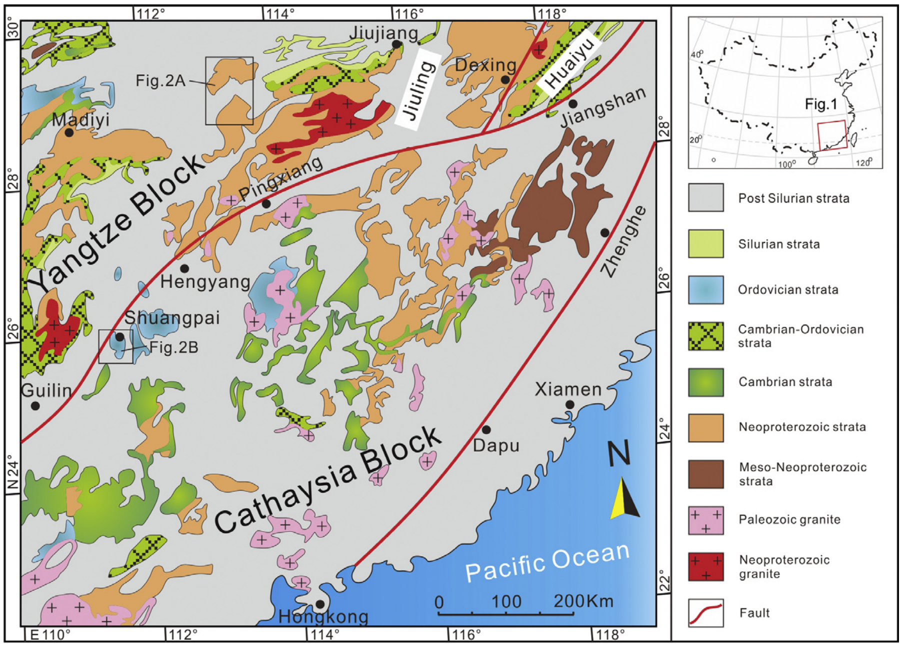

Fig. 1. Geological sketch map of the Yangtze and Cathaysia Blocks.

Xu et al. (2007) and Yu et al. (2009) proposed the existence of 1.8 Ga basement in the Cathaysia. Li (1997) also reported Paleoproterozoic mantle-derived magmatic event in the eastern Cathaysia Block. The Jiangnan Orogen, however, has a younger basement, whose formation age is constrained as post- 1.0 Ga, as only inferred from geochronological investigations of detrital zircons from the basement sequence (Wang et al., 2007a), but not excluding some sedimentary rocks >1.0 Ga. Shortly after the assembly of the Yangtze and Cathaysia Blocks, these two tectonic domains broke up along the Shaoxing–Jiangshan–Pingxiang–Shuangpai fault zone, broadly coeval with the disruption of the Neoproterozoic supercontinent Rodinia. The Cathaysia Block was rifted into Nanhua rift basins and three distinct tectonic domains, namely, the Wuyi, Nanling and Yunkai. The intercontinental rifts between these tectonic domains changed to shallow sea basins (Shu, 2012; Shu et al., 2014). Li et al. (2003c, 2007, 2008) suggested that the initial breakup of the Yangtze–Cathaysia united block started at 830 and lasted until 760 Ma. However, other researchers proposed that the assembly of the Yangtze and Cathaysia Blocks occurred at ca. 850–800 Ma (Wang et al., 2007a; Yao et al., 2013b, 2014a,b), and that the rifting took place at ca. 800 Ma (Wang et al., 2012). Thus, the assembly of these two blocks and the subsequent disruption are still debated.

In the late Ordovician, the above mentioned shallow sea basins were closed and uplifted, leading to metamorphism–deformation as well as the formation of S-type granites in the Cathaysia Block (Shu et al., 2014; Zhang et al., 2011). The pre-Devonian sedimentary rocks and early Paleozoic S-type granites in the Cathaysia Block were then unconformably covered by middle Devonian conglomerate and coarse clastic sequences, whereas the Jiangnan belt displays a continuous deposition. However, the crustal evolution and affinity of both the Jiangnan Orogen and Cathaysia Block have not yet been well constrained.

The Yueyang area is located in the western segment of the Jiangnan Orogen where extensive Neoproterozoic strata are exposed. The Daoxian domain in southwestern Hunan is located in the western margin of the Cathaysia Block, with several outcrops of continuous Early Paleozoic sequence (Fig. 1). We carried out systematic field investigations, geochemistry of sandstones, and zircon U–Pb geochronology and Lu–Hf isotopes on detrital zircons derived from Neoproterozoic and Early Paleozoic meta-sandy rocks in the Yueyang and the Daoxian areas. We report results from 490 detrital zircon U–Pb analyses, 288 Hf isotope determinations and major and trace elements compositions for 14 rock samples. These results provide important constraints on the provenance of the western Jiangnan Orogen and the western Cathaysia Block during Neoproterozoic and early Paleozoic, and shed light into the tectonic setting and affinity of the two tectonic units.

2. Geological background

2.1. Tectonic framework

The Jiangnan Orogen marks the Neoproterozoic northwestward subduction of the Paleo-South China Ocean and collisional suture of the Cathaysia and Yangtze blocks (Charvet, 2013; Charvet et al., 1996; Guo et al., 1989; Li, 1999; Li et al., 1997, 2009, 2012; Shu and Charvet, 1996; Shu et al., 2006; Yao et al., 2011, 2012, 2013a; Xiang and Shu, 2010; Zhang et al., 2011). The final closure of the South China Ocean led to the collision of the Jiangnan magmatic arc with the Cathaysia Block. As a result, the Jiangnan Orogen was constructed parallel to the Shaoxing–Jiangshan–Pingxiang–Shuangpai suture zone (Shu and Charvet, 1996; Shu et al., 2006). The collision resulted in ductile deformation and regional low-greenschist metamorphism of the basement sequence. The ophiolitic complex which contains high-pressure blueschist dated as 866 Ma is widely exposed in the Dongxiang–Dexing–Shexian area (Shu et al., 1994; Shu and Charvet, 1996).

The basement of the Jiangnan belt is composed of strongly deformed early Neoproterozoic metasedimentary and volcanic rocks, which are unconformably covered by the middle Neoproterozoic Nanhua sequence (BGMRHN, 1988). This unconformity is interpreted to have formed as a response to the Neoproterozoic Jiangnan Orogeny (Wang and Li, 2003; Wang et al., 2007a; Yao et al., 2014b). The 900–850 Ma arc-type mafic-ultramafic rocks and ca. 830 Ma S-type granitoids that intruded into the basement sequence are exposed in the various segments of the Jiangnan belt (Shu, 2012; Yao et al., 2014a,b). Shortly after this collision, the South China Craton was rifted along pre-existing faults, generating ca. 800 Ma bimodal igneous rocks in the Nanhua rift basin (Wang and