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Widespread Neoarchean (~2.7–2.6 Ga) magmatism of the Yangtze craton, South China, as revealed by modern river detrital zircons

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ABSTRACT

The Kongling Terrane, which is the Archean nucleus of the Yangtze craton, preserves Paleoarchean-Proterozoic rocks as old as 3.45 Ga. However, the dominant stage of formation of this Archean terrane remains unclear. In this paper, U-Pb and Lu-Hf isotopes of detrital zircons from two rivers and one stream in the northern part of the Kongling Terrane were studied by LA-ICP-MS and LA-MC-ICP-MS, respectively. These zircons show complicated internal structures in cathodoluminescence images, but the majority of them have linear or oscillatory zoning patterns, indicating magmatic origins. In general, the detrital zircons from these three local rivers show similar U-Pb age distributions. Together, they yield age peaks at 3.3–3.1 Ga (5%), 3.0–2.8 Ga (18%), 2.7–2.6 Ga (30%), 2.6–2.2 Ga (15%), 2.0–1.9 Ga (27%), 1.9–1.7 Ga (1%), 1.7–1.5 Ga (2%), and 1.0–0.8 Ga (1%). This age distribution implies that the North Kongling Terrane formed primarily during the Meso- to Neoarchean (3.0–2.6 Ga). Lu-Hf isotopic data reveal predominant subchondritic to chondritic $\varepsilon_{Hf}(t)$ values (−11.3 to 0) for the Mesoarchean zircons, indicating the dominant role of crustal reworking during this period. In comparison, most Neoarchean zircons exhibit near chondritic to suprachondritic $\varepsilon_{Hf}(t)$ values (up to +7.4), suggesting juvenile crustal additions. The 2.0–1.9 Ga zircons have similar initial Hf isotopic compositions as those of the 2.7–2.6 Ga zircons, suggesting a metamorphic recrystallization origin. This observation further implies that the proportion of Neoarchean ages might be underestimated. Previous studies have reported several 2.7–2.6 Ga Archean outcrops, minor detrital zircons in Precambrian sedimentary rocks and xenocrystal zircons in volcanic rocks from the Yangtze craton. Combined with our data, we propose that the 2.7–2.6 Ga magmatism may have played an important role in forming the Kongling Terrane and have widely affected other parts of the Yangtze craton as well, similar to many other Archean cratons worldwide. The ~2.7–2.6 Ga may correspond to the initial stabilization of the Archean nucleus of the Yangtze craton. Thereafter, this craton shows comparable 2.5–2.2 Ga age records to the recently proposed Nunavutia supercraton, which could provide further clues to the early tectonic process of the Yangtze craton.

1. Introduction

The Neoarchean is one of the most important periods for studying the formation of the Earth's crust. Significant changes have been documented to approximately 2.7–2.6 Ga, including the possible initiation of subduction-collision plate tectonics on a global scale, the formation of voluminous continental crust, and the cratonization of many Archean cratons (e.g., Bradley, 2011; Eriksson et al., 2013; Laurent et al., 2014). Thus far, the corresponding records of the 2.7–2.6 Ga magmatism and metamorphism have been widely documented in many Archean cratons, e.g., the Superior craton in North America (Polat and Münker, 2004; Davis et al., 2005; Ketchum et al., 2008; Bedard and Harris, 2014), the Yilgarn craton in Australia (Ivanic et al., 2012; Wyche et al., 2012), the Dharwar craton in South Asia (Sunder Raju et al., 2013; Glorie et al., 2014; Khanna et al., 2014), and the North China and Tarim cratons in East Asia (Zhai and Santosh, 2011; Yang et al., 2013; Zong et al., 2013; Ge et al., 2014; Wan et al., 2014).

The Yangtze craton is one of the largest ancient cratons in eastern Asia. Recent studies on granitoid gneisses revealed the existence of Paleoarchean rocks as old as 3.4–3.3 Ga from the Kongling Terrane, which is the Archean nucleus located in the northern part of the Yangtze craton (Gao and Zhang, 1990; Jiao et al., 2009; Gao et al., 2011; Guo et al., 2014). However, the early evolutionary history of this craton is still poorly understood, due to the heavy vegetation and uncommon Archean outcrops. Detrital zircons from fine-grained sediments could retain their primary isotopic information during subsequent transportation and sedimentation. Thus, U-Pb and Lu-Hf isotopes of detrital zircons have been widely used in provenance studies and evaluation of regional tectono-thermal events, as well as to determine the crustal

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growth and reworking history (e.g., Hawkesworth and Kemp, 2006; Zhang et al., 2006c; Sun et al., 2008; Yang et al., 2009; Condie and Aster, 2010; Hawkesworth et al., 2010; Iizuka et al., 2010; Condie et al., 2011; Lancaster et al., 2011; Cawood et al., 2013; He et al., 2013).

In this study, we conducted 323 U-Pb and 190 Lu-Hf isotope analyses on detrital zircons from three modern rivers (Gongjia River, Wudu River, and Bianyuchi Stream) crossing the northern part of the Kongling Terrane. The new dataset suggests that the 2.7–2.6 Ga granitoid magmatism dominates the northern part of the Kongling Terrane. Together with previous studies of Neoarchean zircons and rocks in the Yangtze craton, the ~2.7–2.6 Ga magmatism appears to have widely affected the Yangtze craton.

2. Geological background and sample descriptions

The Yangtze craton is separated from the North China craton by the Qinling-Dabie-Sulu orogen to the north and from the Cathaysia block by the Jiangnan orogen to the southeast. It is also connected to the Tibetan Plateau in the west (Fig. 1A). The Yangtze craton is mainly covered by Proterozoic rocks with only sporadic outcrops of Archean rocks, such as the Kongling Terrane, Huangtuling granulite, Yudongzi group, Houhe complex, and Douling complex in the northern part of the Yangtze craton (Gao and Zhang, 1990; Qiu et al., 2000; Zhang et al., 2001, 2006a, 2006b; Sun et al., 2008; Wu et al., 2008; Jiao et al., 2009; Gao et al., 2011; Wu et al., 2012; Chen et al., 2013a; Guo et al., 2014; Wu et al., 2014). Moreover, minor Archean xenocrystal zircons in volcanic rocks and detrital zircons from sediments were found throughout the Yangtze craton, which may also imply a broad spatial extent of Archean rocks (Zheng et al., 2006; Zhao and Cawood, 2012; Zhang and Zheng, 2013).

The Kongling Terrane is the only well-documented Archean basement of the Yangtze craton. According to the lithology and geochronology, it can be divided into two segments: the South and North Kongling Terranes (Fig. 1B) (Qiu et al., 2000; Gao et al., 2011; Zhao and Cawood, 2012). The South Kongling Terrane is dominated by the Neoproterozoic Huangling batholith (Zhang et al., 2009a). In striking contrast, the North Kongling Terrane comprises Archean-Paleoproterozoic granitoid gneisses and metasedimentary rocks (metapelites, metasandstones and marbles), with minor amphibolites and mafic granulites that occur as lenses or boudin layers in the gneisses (Gao and Zhang, 1990; Gao et al., 1999). Previous studies revealed that the granitoid gneisses are primarily 3.3–2.9 Ga tonalite-trondhjemite-granodiorite (TTG) and 2.8–2.0 Ga granites. Both the TTG and granites were pervasively overprinted by a 2.0 Ga high-grade metamorphic event and intruded by the 1.85 Ga Quanyishang A-type granite (Fig. 1C) (Guo et al., 2015). The 2.0 Ga geological process resulted in (1) widespread amphibolite to high-pressure granulite facies metamorphism in the pre-existing granitoid and metasedimentary rocks (Zhang et al., 2006a, 2006c; Wu et al., 2009; Gao et al., 2011; Yin et al., 2013; Chen et al., 2013a; Guo et al., 2014) and (2) crustal anatexis that produced voluminous S-type granites (Yin et al., 2013; Li et al., 2014).

In this study, sand samples from three local rivers (Gongjia River, Wudu River, and Bianyuchi Stream) in the North Kongling Terrane were collected (Fig. 1C). In general, the watersheds of the Gongjia and

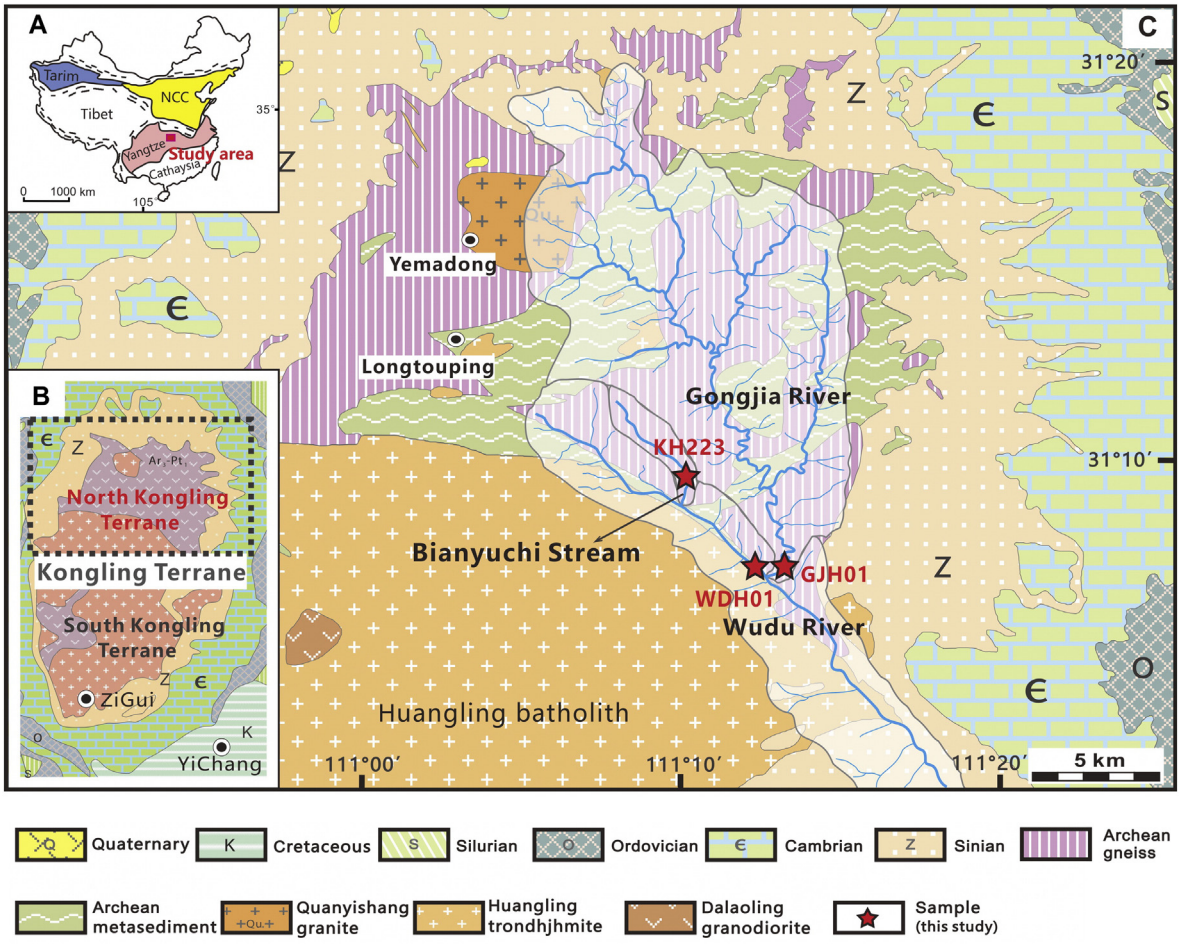

Fig. 1. (A) Simplified tectonic map of China, where the North China craton is abbreviated to 'NCC'. (B) Structure and division of the Kongling Terrane, modified from Liu et al. (2008). (C) Geological map of the North Kongling Terrane and the drainage areas (in gray) of the Gongjia River, Wudu River and the Bianyuchi Stream. The red stars represent the sample locations in this study.