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Precambrian continental crust evolution of Hainan Island in South China: Constraints from detrital zircon Hf isotopes of metaclastic-sedimentary rocks in the Shilu Fe-Co-Cu ore district

Shaohao Zou [a,b], Liangliang Yu [c,d], Deshui Yu [a,b], Deru Xu [a,*], Tingwei Ye [a,b], Zhilin Wang [e], Jianxin Cai [f], Meng Liu [a,b]

[a] Key Laboratory of Mineralogy and Metallogeny, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China
[b] University of Chinese Academy of Sciences, Beijing 100049, China
[c] School of Earth Science and Geological Engineering, Sun Yat-sen University, Guangzhou 510275, China
[d] Center for Earth Environment & Resources, Sun Yat-sen University, Guangzhou 510275, China
[e] School of Geosciences and Info-Physics, Central South University, Changsha 410083, China
[f] Key Laboratory of Marginal Sea Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China

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ABSTRACT

Combined with the previous detrital zircons U-Pb ages of the two Precambrian successions, i.e. the Shilu Group and the Shihuiding Formation in Hainan Island of South China, the *in situ* Lu-Hf isotopes of detrital zircons were performed to evaluate the growth and reworking of Hainan Island continental crust during Precambrian. The results of 171 Hf-isotopic analyses on zircon grains from the Shihuiding Formation yield $^{176}Hf/^{177}Hf$ ratios between 0.280786 and 0.281188, $^{176}Lu/^{177}Hf$ ratios between 0.000228 and 0.003388, Hf model ages (T_{DM}^{C}) between 3.8 Ga and 1.2 Ga, and $\varepsilon_{Hf}(t)$ values ranging from −12.5 to +10.6. The analyzed results of 272 Hf-isotopic data on zircon grains from the Shilu Group exhibit a wide range of $^{176}Hf/^{177}Hf$ ratios (0.280810–0.282512), $^{176}Lu/^{177}Hf$ ratios (0.000062–0.004060), T_{DM}^{C} ages (3.7 Ga–1.1 Ga), and $\varepsilon_{Hf}(t)$ values (−20.5 to +12.3).

The continental crust of Hainan Island maybe appeared firstly at ca. 4.0–3.8 Ga and then was reworked. The 91.8% of detrital zircon grains from the Shihuiding Formation and 93.8% of the ones from the Shilu Group have crustal incubation time larger than 300 Ma, indicating an involvement of reworked materials into the sedimentation of both the successions. Unambiguously, the crustal basement rocks in Hainan Island were formed mainly through reworking the previous continental components with minor input of juvenile materials. The generation of juvenile curst in Hainan Island predominantly occurred at ca. 2.7 Ga and ca. 1.5–1.0 Ga, which are consistent with that for the assembly of the Kenorland, and the Columbia breakup and subsequent amalgamation of the Rodinia, respectively. The present study further reveals that the crustal growths in Hainan Island are present at 2.7 Ga, 2.3 Ga and 2.1–1.8 Ga, which is more favorable to the episodic growth mode. Moreover, a rough trend of decreasing maximum crustal incubation time of Hainan Island demonstrates that the incubation time of the juvenile crust is shorter when compared with that of the Cathaysia Block in the late Mesoproterozoic. Link to the previously reported geological works, we consider that Hainan Island did not share the same evolution history with the Cathaysia Block of South China during Precambrian.

1. Introduction

Hainan Island, an epicontinental-type island, is located on the northern margin of the South China sea (Fig. 1a) and characterized by multistage continental rifting and assembly as well as episodic crustal growth likely since late Archean (Xu et al., 2001, 2015; Wang et al., 2013a). The most important epochs for the Hainan crustal growth likely include Paleoproterozoic of ca. 2.0 Ga age and late Mesoproterozoic to early Neoproterozoic of ca. 1.0 Ga age (Zhang et al., 1997; Xu et al., 2001), which probably are linked to the evolutions of the Paleoproterozoic to Mesoproterozoic Columbia supercontinent (e.g., Rogers and Santosh, 2002, 2009; Zhao et al., 2002, 2004; Kusky and Santosh, 2009) and the Meso-

* Corresponding author.
E-mail address: xuderu@gig.ac.cn (D. Xu).

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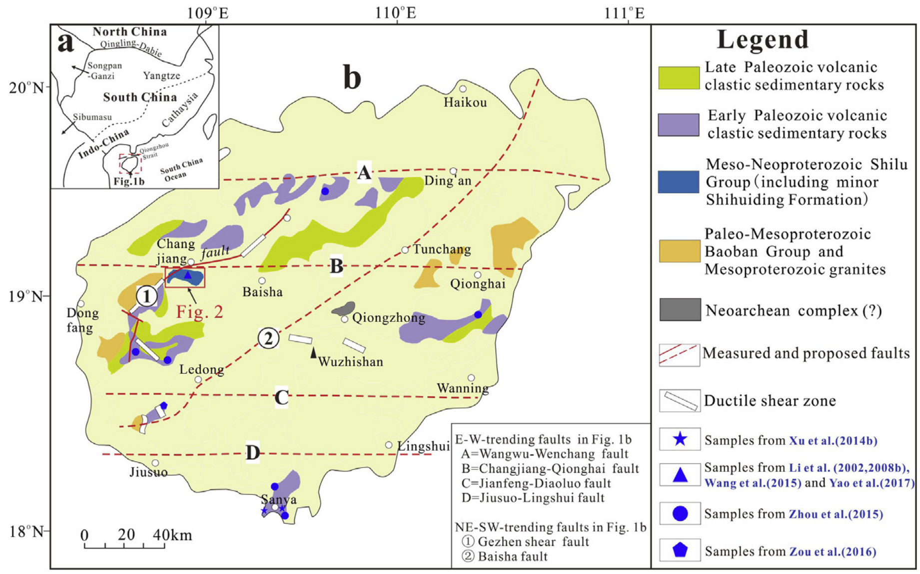

Fig. 1. (a) Distributions of principal continental blocks of Southeast Asia and the Indosinian Fold Belt in South China (after Metcalfe, 2013); (b) Simplified geological map showing the Precambrian to Paleozoic rocks in Hainan Island (after Xu et al., 2013). The locations of the collected samples from Hainan Island are shown in (b).

proterozoic to Early Neoproterozoic Rodina supercontinent (e.g., Hoffman, 1991; Rivers, 1997; Condie, 2000; Fitzsimons, 2000; Rino et al., 2008), respectively. Previous reconstructions of Rodinia supercontinent usually placed Hainan Island as part of the Cathaysia Block, South China (Li et al., 1995) and thus, South China (including Hainan Island) was considered to be situated between western Laurentia and southeastern Australia in the Rodinia (Li et al., 2002, 2008a,b, 2014), on the basis of the presence of the Mesoproterozoic (ca. 1.43 Ga) magmatic rocks in Hainan Island. In contrast, Duan et al. (2011), Zhao and Cawood (2012), and Cawood et al. (2013) proposed that the South China was located on the periphery of Rodinia near western Australia and India based on zircon U-Pb geochronological data from both the Yangtze and Cathaysia blocks of South China. Similarly, Yu et al. (2008, 2009, 2010) argued that the South China lay adjacent to India and East Antarctica (northern Gondwana) during the period from the breakup of Rodinia to assembly of Gondwana through studying the late Neoproterozoic basement metamorphic rocks in the southern Cathaysia Block. Furthermore, Wang et al. (2015) tentatively proposed that Hainan Island was independent of South China at least before the late Ordovician and most likely attached or close to northwestern Laurentia before the breakup of Rodinia, based on recent U-Pb dating on detrital zircons. Nevertheless, these compelling models were largely based on sampling from the distinctive blocks, which show a different crustal evolutionary history during Mesoproterozoic (Zhao and Cawood, 2012). Therefore, it is necessary to clarify the Precambrian crustal evolutionary histories of the isolated blocks such as Hainan Island and South China before figuring out their locations in Precambrian supercontinents (e.g., the Rodinia) as well as evaluating the relationships between these isolated blocks during supercontinent cycles.

Inferences about the continental crust evolution have largely come from the study of neodymium and hafnium isotope systematics (Armstrong, 1981; Bennett et al., 1993; Vervoort et al., 1996; Hawkesworth and Kemp, 2006b; Kemp et al., 2006; Kemp and Hawkesworth, 2013; Vervoort and Kemp, 2016). Since the Nd isotope system cannot resolve individual periods of crustal growth and the Hf isotopic analysis technology has gained great progresses, zircon Hf isotope data have been used increasingly to constrain the growth and differentiation of the continental crust (Vervoort and Kemp, 2016). In addition, because of its high closure temperature, zircon is stable up to high metamorphic grades and also resistant to diffusion and isotopic exchange (Griffin et al., 2002). Consequently, the low Lu/Hf value in zircon makes it possible to determine the initial $^{167}Hf/^{177}Hf$ ratios and to estimate the differentiation of mantle and crustal (Vetrin et al., 2016). In this contribution, the *in situ* Lu-Hf isotopes of detrital zircons collected from the late Mesoproterozoic to early Neoproterozoic Shilu Group and the early Neoproterozoic Shihuiding Formation were performed to evaluate the growth and reworking of Hainan Island continental crust during Precambrian. Combined with previous reported studies, we further discussed the time of crust-mantle differentiation histories and the crustal evolution mode in Hainan Island as well as suggested the relationship between Hainan Island and the Cathaysia Block of South China before or during the assembly of Rodinia.

2. Regional geological background

South China comprises the Cathaysia Block in the southeast and the Yangtze Block in the northwest (Fig. 1a), which were amalgamated during the Neoproterozoic due to the assembly of Rodinia (Li et al., 2009). Hainan Island, separated from South China mainland by the Qiongzhou Strait (Fig. 1a), lies at the joint of the Eurasian plate, Indian-Australian plate and Pacific plate which makes the Island especially significant for understanding the continental margin accretion and evolution of East Asia (Xu et al., 2013). However, the limited exposure and the multistage deformation of crystalline basement rocks led to diverse interpretations on the tectonic division of Hainan Island. Hsü et al. (1990) and Chen et al. (1992) suggested that Hainan Island consists of a northwestern section as part of the Cathaysia Block and a southeastern extension of Subumasu, with both the blocks collided along the so-called "Shilu mélange" belt during the Mesozoic. On the other hand, Metcalfe (1994, 1996) divided Hainan Island into the northwestern and the southeastern Hainan terranes, which sutured along the NE-trending Baisha fault during the late Paleozoic (Xu et al., 2007a). Taking the nearly E–trending Jiusuo–Lingshui fault zone as a boundary (Fig. 1b), Hainan Island was divided into a northerly Wuzhishan Terrane and a southerly Sanya Terrane (HBGMR, 1997) with both being Gondwana affiliated (Xu et al., 2014b). However, these distinct schemes of dividing the Hainan