Precambrian Research 222–223 (2012) 424–449

Contents lists available at ScienceDirect

Precambrian Research

journal homepage: www.elsevier.com/locate/precamres

U–Pb geochronology and Hf–Nd isotopic geochemistry of the Badu Complex, Southeastern China: Implications for the Precambrian crustal evolution and paleogeography of the Cathaysia Block

Jin-Hai Yu[a,b,d,*], Suzanne Y. O'Reilly[b], Mei-Fu Zhou[c], W.L. Griffin[b], Lijuan Wang[a,b]

[a] State Key Laboratory for Mineral Deposits Research, School of Earth Sciences and Engineering, Nanjing University, Nanjing 210093, China
[b] GEMOC ARC National Key Centre, Department of Earth and Planetary Sciences, Macquarie University, Sydney, NSW 2109, Australia
[c] Department of Earth Sciences, University of Hong Kong, Hong Kong, China
[d] State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan 430074, China

ARTICLE INFO

Article history:
Received 28 February 2011
Received in revised form 6 July 2011
Accepted 15 July 2011
Available online 9 September 2011

Keywords:
Precambrian crustal evolution
Reconstruction of Cathaysia in Columbia
Zircon U–Pb–Hf isotope
Badu Complex
South China

ABSTRACT

The oldest rocks of the Cathaysia Block, South China, comprise the Badu Complex and Paleoproterozoic granites in the Wuyishan area (southern Zhejiang and northwestern Fujian Provinces). New zircon U–Pb ages, Hf isotopes and trace elements for metamorphic rocks from the Badu Complex, and bulk Nd-isotope compositions of these rocks and granites in the Wuyishan area provide important constraints on the Precambrian crustal evolution of the Cathaysia Block. Inherited cores of zircon grains from the metamorphic rocks are of magmatic origin, predominantly formed at ca 2.5 Ga, while overgrowth rims reflect two episodes of granulite–facies metamorphism related to collisional orogeny at 1.89–1.88 Ga and 252–234 Ma. The unimodal age distribution (~2.5 Ga) of detrital zircons and the positive $\varepsilon Hf(t)$ of most Neoarchean zircons suggest that the detritus of these sedimentary protoliths of the Badu Complex came from a proximal volcanic arc, and that they were deposited in an arc basin synchronously with ~2.5 Ga volcanism. Zircon U–Pb ages and Hf-isotopes with whole-rock Nd isotopes suggest that the juvenile crust of the eastern Cathaysia Block was generated mainly at 2.5 Ga and 2.8 Ga, and minor at 3.5–3.3 Ga with some evidence for the generation at 3.7–3.6 Ga and ~4.0 Ga. A strong ~1.9 Ga orogeny and the 3.3–3.0 Ga thermal event only involved the reworking of older crust material. Paleoproterozoic (1.89–1.86 Ga) granitic magmatic activity and high-grade metamorphism in the eastern Cathaysia Block were synchronous with the assembly of the Columbia supercontinent. Using integrated geochronological, Hf–Nd isotopic and petrologic data as a "barcode", we compare the Cathaysia Block with other Paleoproterozoic orogens worldwide, and argue that its closest affinity is with the South Korean Peninsula and the Lesser Himalaya of NW India. Consequently, the eastern Cathaysia block, and the South Korean massif (as the united Cathay-South Korea terrane) was close to the Lesser Himalaya terrane in the Paleoproterozoic configuration of the Columbia supercontinent. The spatial linkage was maintained for ca 1 Ga, until the fragmentation of the Rodinia supercontinent during Neoproterozoic time.

1. Introduction

The assembly and breakup of supercontinents are currently one of the most attractive and important issues in solid – Earth geology. The supercontinent cycle is a major driving process that has provided the impetus for many of the important developments in Earth's history (Rao and Reddy, 2002). Comparison of paleomagnetic, lithological and structural data from coeval rocks in various continents provides constraints on the reconstruction of supercontinents, especially for the younger ones such as Gondwanaland and Pangea. However, paleomagnetic information in old rocks can be erased by tectonothermal overprinting. Therefore, stratigraphical, lithological, geochronological and geochemical data are increasingly used to establish former linkages between separated blocks in the Proterozoic supercontinents, such as Columbia and Rodinia (Karlstrom et al., 2001; Rogers and Santosh, 2002; Li et al., 2002, 2003; Zhao et al., 2002, 2004; Yu et al., 2008; Howard et al., 2009; Bhowmika et al., 2010).

The South China Block (SCB) is an important Precambrian terrain, which is composed of the Yangtze and Cathaysia blocks (Fig. 1a). Its paleogeography in the Rodinia supercontinent has been discussed by many researchers based on the different types of geological observations (Li et al., 1995, 2002; Jiang et al., 2003; Yang et al., 2004; Zhou et al., 2002a, 2006; Wang et al., 2008; Yu et al., 2008). However, its early Precambrian evolution, especially for Cathaysia, has not been well understood, and its position

* Corresponding author. Tel.: +86 25 83686183; fax: +86 25 83686016.
E-mail address: jhyu@nju.edu.cn (J.-H. Yu).

0301-9268/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.precamres.2011.07.014

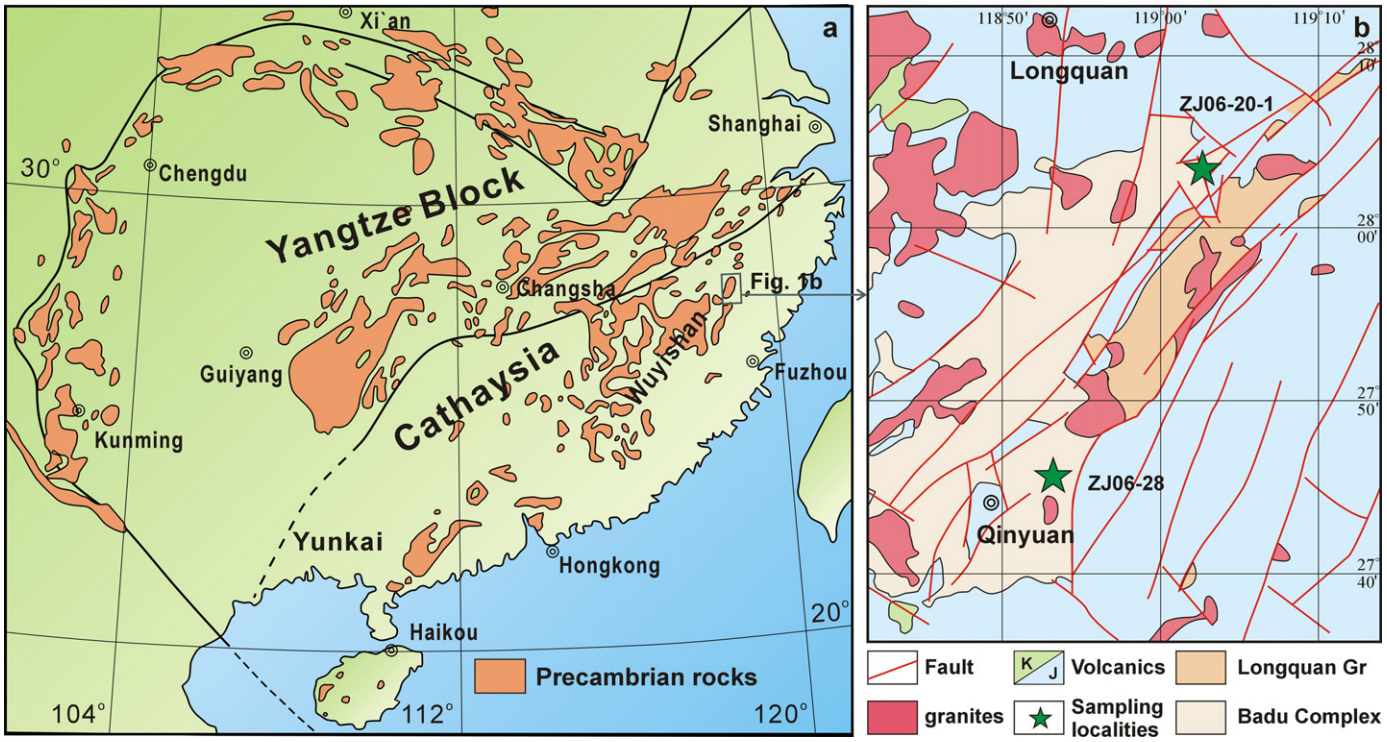

Fig. 1. Sketch geological map of South China showing the study area.

in the Paleoproterozoic supercontinent Columbia and its relationship with other continental blocks have not been well constrained, due to the sparse outcrops of pre-Mesoproterozoic basement rocks and an absence of paleomagnetic data. Recently, a Paleoproterozoic orogeny has been recognized in the eastern Cathaysia Block, suggesting that South China was probably part of the supercontinent Columbia (Yu et al., 2009). This paper presents new whole-rock Nd-isotope compositions and trace-elements, U–Pb ages and Hf-isotopes of zircons from metamorphic rocks in the eastern Cathaysia Block. The new dataset helps us to unravel the early Precambrian crustal evolution of the Cathaysia Block and its relationship with other blocks within Columbia.

2. Geological background and sampling

South China is composed of the Yangtze Craton to the northwest and the Cathaysia Block to the southeast (Fig. 1a). These two blocks have different histories of Precambrian crustal evolution and were brought together during early Neoproterozoic time (1000–800 Ma; Shu et al., 1994; Zhao and Cawood, 1999; Li et al., 2002, 2008, 2009; Ye et al., 2007; Wang et al., 2007, 2010a,b; Zhao et al., 2011). Neoarchean basement is widespread in the Yangtze Craton (Zheng et al., 2006; Zhang et al., 2006a; Wang et al., 2010a) and a Mesoarchean core is present in the northern part (Kongling area) (Qiu et al., 2000; Zheng et al., 2006; Jiao et al., 2009). Neoproterozoic (740–840 Ma) granitic and mafic magmatism was important around the Yangtze craton (Li, 1999; Zhou et al., 2002a, 2002b; Li et al., 2003; Wang et al., 2006, 2010a; Wu et al., 2006; Zheng et al., 2004, 2007, 2008). Minor ~1.7 Ga volcanic rocks (Greentree and Li, 2008) and 1.1–0.9 Ga igneous rocks are exposed along the western and southeastern margins of the Yangtze Block (Greentree et al., 2006; Ye et al., 2007; Li et al., 2009). In contrast, the Cathaysia Block is characterized by voluminous Phanerozoic igneous rocks, particularly Mesozoic granitoids, and quite sparsely exposed Precambrian metamorphic basement rocks (Fig. 1). In the northern Wuyishan area, eastern part of the Cathaysia Block, Precambrian rocks are most abundant. Most metamorphic rocks in this area were previously considered to have Paleo-Mesoproterozoic and even Neoarchean ages (Hu et al., 1991; Gan et al., 1995; Li, 1997; Zhuang et al., 2000). However, many of them have recently been demonstrated to have formed in the Neoproterozoic and even later (Li et al., 2005, 2010; Yu et al., 2005; Wan et al., 2007; Shu et al., 2011); the Archean ages obtained by the Sm-Nd isochron method are probably unreliable (Li, 1997). New zircon U–Pb dating results indicate the existence of Paleoproterozoic S-type granites and high-grade metamorphic rocks in the northern Wuyishan area (Gan et al., 1995; Li and Li, 2007; Yu et al., 2009; Liu et al., 2009), suggesting that there was a Paleoproterozoic orogeny in the Cathaysia, probably related to the assembly of the supercontinent Columbia.

Precambrian sequences in the northern Wuyishan area were generally assigned as the Paleoproterozoic Badu "Group" and Mesoproterozoic Longquan Group (Hu et al., 1991). However, the Badu "Group" is not a homogeneous unit, and the mafic rocks in the Tangyuan "Formation" at the bottom of the Badu "Group" are not Paleoproterozoic (Yu et al., 1995; our unpublished data). Therefore, the Badu "Group" probably should be named as the "Badu Complex". The Longquan Group is composed mainly of mica-quartz schist, epidote amphibolite, actinolite schist, fine-grained biotite gneiss, magnetite-bearing quartzite and marble, suggesting that the protoliths were mafic volcanic rocks and pelitic–arenaceous–calcareous sedimentary rocks. Dating of some granitoids intruding the Badu Complex suggests that the complex formed before 1888 Ma (Yu et al., 2009). The Longquan Group is more likely to have formed in the Neoproterozoic, based on the similarity of its rock assemblages to the Neoproterozoic Chencai Group in northern Zhejiang Province (Yu et al., 1995; Li et al., 2010) and the Mamianshan Group in the southern part of the Wuyishan area (northern Fujian Province) (Li et al., 2005; Shu et al., 2011). These Precambrian rocks are intruded by early Paleozoic and late Mesozoic granites, or covered by Paleozoic sediments and late Mesozoic volcanic rocks (Fig. 1b), especially along the coastal area of Southeastern China.