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Paleoproterozoic tectonic transition from collision to extension in the eastern Cathaysia Block, South China: Evidence from geochemistry, zircon U–Pb geochronology and Nd–Hf isotopes of a granite–charnockite suite in southwestern Zhejiang

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ABSTRACT

The Badu complex and associated Paleoproterozoic granitoids are among the oldest known rocks in the Cathaysia Block in South China. The Paleoproterozoic units of the Badu complex are dominantly composed of metapelitic rocks and meta-greywackes. Here we report LA-SS-ICP-MS (laser ablation-split-stream inductively coupled plasma-mass spectrometry) zircon U–Pb data from a newly discovered garnet-bearing granite which show an emplacement age of 1929 ± 15 Ma and metamorphism at 1872 ± 34 Ma. We also report U–Pb ages of 1886 ± 16 Ma, 1858 ± 7 Ma, 1848 ± 11 Ma from a gneissic granodiorite, and two charnockites respectively. The garnet-bearing granite is peraluminous with A/CNK range from 1.1 to 1.3. The rock shows relatively high SiO_2, K_2O and Rb contents, and low total REE, Sr, CaO and ferromagnesian components, typical of leucogranites. The whole rock Nd two-stage model age(T_{DM2}(Nd)) of this rock is ca. 2.7 Ga, zircon Hf crustal model ages(T^C_{DM}(Hf)) peak at about 2.7 Ga, and abundant inherited zircons occur with U–Pb ages in the range of 2044 to 2803 Ma. Evidences from zircon U–Pb age and Hf isotope compositions, whole rock Nd isotopes and whole rock major and trace elements suggest a metasedimentary protolith, and that the garnet-bearing granite (leucogranite) was derived by partial melting in a thickened crust at about 1.93 Ga. The gneissic granodiorite and charnockites show indistinguishable major and trace element features, as well as zircon Hf and whole rock Nd isotope compositions, indicating that they were generated from the same source rocks. The gneissic granodiorite and charnockites are ferroan, calc-alkalic and metaluminous with A/CNK range from 0.80 to 0.98. They display relatively low SiO_2 contents and Ga/Al ratios, suggesting their A-type affinity. Their zircon T^C_{DM}(Hf) age-peak is 2.9 Ga and whole rock T_{DM2}(Nd) ages range from 2.8 to 2.9 Ga. These high temperature rocks were generated possibly through the partial melting of ancient amphibolites (2.9 Ga), with heat input from asthenosphere upwelling and magmatic underplating in an extensional setting at about 1.85–1.88 Ga.

Combined with data from previous studies, we suggest three episodes of major crustal growth in this region at 1.8–1.9 Ga, ~2.7 Ga and ~2.9 Ga. During the 1.8–1.9 Ga event, extensive reworking also took place. From the 1.93 Ga syn-collision leucogranite (garnet-bearing granite), the 1.88–1.85 Ga post-collision A-type granites and charnockites (the granite–charnockite suite), and the1.85–1.77 Ga intraplate basaltic rocks (Li 1997 and Xiang et al. 2008) in the region, a Paleoproterozoic orogenic cycle can be deciphered in the Cathaysia Block. The rapid transition of tectonic regime from collision to post-collisional extension can be correlated to the assembly of the supercontinent Columbia.

1. Introduction

Granites and charnockites have been the subject of many studies as they constitute the dominant rock types in many Precambrian terranes, and have therefore important implications in understanding the crustal evolution history as well as the growth and evolution of continents and supercontinents (Bonin, 2007; Rajesh and Santosh, 2004, 2012; Touret

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and Huizenga, 2012). The formation of granite–charnockite suites of rocks are also closely connected with tectonics and geodynamic processes (Eby, 1992; Maniar and Piccoli, 1989; Pearce et al., 1984; Whalen et al., 1987, among others). Granites and charnockites have also been used as petrological probes into the deep continental crust (Bonin, 2007), especially charnockites, which are considered to represent the dehydrated lower crust characterized by low aH_2O, high temperature, and with or without high CO_2 concentration (Friend, 1981; Grantham et al., 2012; Janardhan et al., 1979; Kilpatrick and Ellis, 1992; Rajesh and Santosh, 2004; Santosh and Omori, 2008; Santosh et al., 1991; Zhang et al., 2011 and references therein). Charnockites, orthopyroxene-bearing granitoids (Le Maitre, 2002) of both magmatic and metamorphic origin (Rajesh and Santosh, 2012), are common in many high-grade terranes, often associated with other granulite-facies metamorphic complexes of arc-accretionary origin or post-collisional extensional setting (Chen et al., 2012; Frost and Frost, 2008; Rajesh, 2008; Santosh et al., 2012; Shen and Ji, 1992; Songbai et al., 2006; Su et al., 1999; Y. Wang et al., 2013; Zhang et al., 2010). The petrology, geochemistry and isotopic characteristics of charnockitic rocks have been widely employed to decipher the tectonic regimes in which these rocks were formed (Frost and Frost, 2008; Ma et al., 2013; Mikhalsky et al., 2006a,b; Rajesh and Santosh, 2004; Zhou et al., 1995).

The Southwestern Zhejiang region (SZR) forms the northern part of the Wuyishan terrane (Yu et al., 2010; Yu et al., 2012; Yu et al., 2009) in the NW domain of the Cathaysia Block in South China (Fig. 1). To the northwest of the SZR is the well-known Neoproterozoic Jiangnan Orogen which is considered to be a suture between the Cathaysia Block in the southeast and the Yangtze Block in the northwest to form the South China Craton (Charvet, 2013; L. Wang et al., 2008; Li et al., 1997, 2002, 2009; Shu and Charvet, 1996; W.X. Li et al., 2008; Ye et al., 2007; Zhang et al., 2013; Zheng et al., 2008). The Jiangshan–Shaoxing fault marks the northwestern boundary of the SZR and the Jiangnan Orogen. The Lishui–Yuyao fault is the southwestern boundary of the SZR and the coastal area of the Cathaysia Block that is dominated mainly by Cretaceous magmatic rocks (140–100 Ma) (Xu et al., 2007). The SZR is a high-grade metamorphic terrane that experienced granulite-facies metamorphism (Yu et al., 2012; pelitic granulite recorded clockwise p–T path and peak metamorphic T and P conditions: 800–850 °C, 0.6–0.7 GPa. See more details in Zhao and Zhou, 2012). Paleoproterozoic basement rocks, mainly the metasedimentary rocks of the Badu Group and the granites that intruded into them, outcrop sporadically in the region (Fig. 1). Paleoproterozoic basaltic rocks (1.77 Ga) also outcrop in the SZR, Li (1997) studied these rocks and got the conclusion that these mantle-derived intraplate basaltic rocks were emplaced in the extensional setting. And also their emplacement and underplating not only triggered the cratonization of the Cathaysia Block by heating ancient crustal materials to generate the 1.8–1.9 Ga granites in the region, but they also represent juvenile continental crust. This point is confirmed by zircon U–Pb and Hf isotope data from Xu et al. (2007) and Xia et al. (2012) which show that considerable juvenile crustal

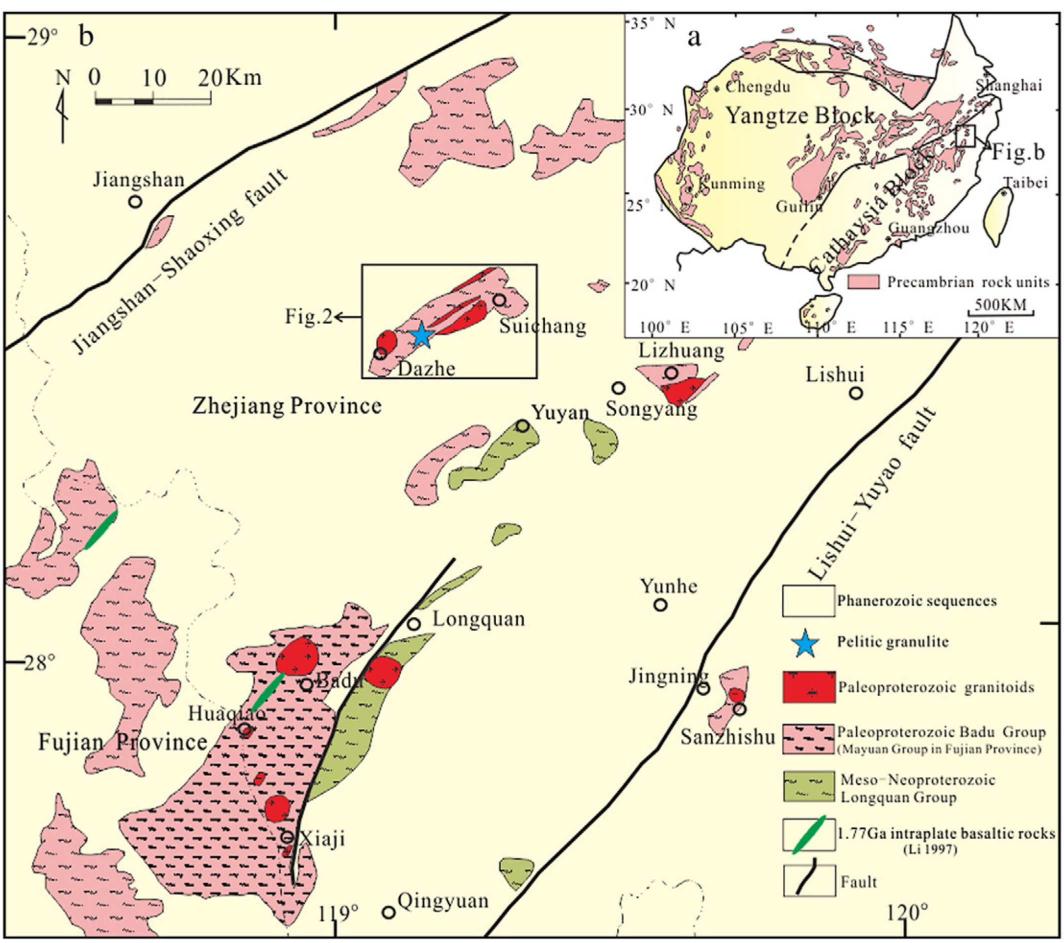

Fig. 1. Simplified geological map of South China (a) and the region of southeastern Zhejiang (RSZ) (b). (a) Distribution of Precambrian rock units in South China; (b) Paleoproterozoic Badu Group (Badu Complex) and granitic intrusions, Meso- to Neoproterozoic Longquan Group.
This map is modified after Hu et al. (1991), Li (1997), Liu et al. (2009), Xia et al. (2012) and Yu et al. (2007, 2012).