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Late Early Paleozoic and Early Mesozoic intracontinental orogeny in the South China Craton: Geochronological and geochemical evidence

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ABSTRACT

The late Early Paleozoic and Early Mesozoic tectonic events in South China have been central to the debate over plate subduction versus intracontinental orogeny. Here we present zircon U–Pb geochronology, Hf isotopes and whole-rock geochemistry of six representative granitic plutons from South China. The zircon data show two groups with $^{206}Pb/^{238}U$ ages of ca. 430 Ma and 225 Ma, representing the crystallization ages of magma. The six plutons investigated in this study are characterized by peraluminous nature with high A/CNK values (>1.1) and the presence of aluminous minerals like muscovite. They exhibit enrichment in LREE, depletion in Eu, negative Ba, Sr, Nb and Ti anomalies and enrichment in Rb, Th, U and Pb. All samples show variably negative $\varepsilon_{Hf}(t)$ values (−2 to −16) with two-stage Hf model ages clustered around 1.5–1.8 Ga. These data indicate that both the Early Paleozoic and Early Mesozoic granitic magmas were generated by the partial melting of early-middle Paleoproterozoic basement rocks without significant input of mantle material. The distribution of all the plutons with ages around 430 Ma and 225 Ma are unrelated to subduction tectonic regime. Combining with other geological evidence, our study suggests that the tectono-magmatic events during late Early Paleozoic and Early Mesozoic were largely related to intracontinental orogeny triggered by interactions between the Yangtze and Cathaysia continental blocks. The far-field stress propagation derived from the South China plate boundary might have played a crucial role as the primary cause of the stress field within the continental interior of the South China Craton.

1. Introduction

The South China Craton (SCC) is composed of the Yangtze and Cathaysia blocks which were amalgamated during Neoproterozoic along the Jiangshan–Shaoxing–Pingxiang–Guanxian Fault (Charvet et al., 1996; Guo et al., 1989; Li et al., 2009; Shu, 2012; Shu and Charvet, 1996; Shu et al., 2011, 2014; Yao et al., 2013). During the Phanerozoic, the SCC was reworked by three intense tectonothermal events in the Early Paleozoic, the Early Mesozoic and the late Mesozoic (Shu et al., 2008a, 2011; Shu, 2012; Wang and Shu, 2012). The Early Paleozoic tectono-magmatic event is characterized by the regional absence of Silurian strata except the Jiangnan domain and the angular unconformity between the Ordovician marine deposition and the middle Devonian terrestrial coarse-clastic sequences. Meanwhile, the Pre-Devonian strata experienced greenschist facies metamorphism and strong deformation (Charvet, 2013; Li et al., 2010; Shu, 2012; Shu et al., 2008b, 2014), which are manifested by isoclines, overturned folds and thrust sheets (Charvet et al., 2010; Guangdong BGMR, 1988; Hunan BGMR, 1988; Jiangxi BGMR, 1984). The Early Mesozoic event is marked by the regional angular unconformity between middle Triassic and upper Triassic formations (Yang et al., 1982). This event also generated a series of brittle and ductile deformation fabrics and thrust faults (Shu, 2012; Shu et al., 1998). Both events resulted in partial melting of continental crust, thus generating large-scale late Early Paleozoic and Early Mesozoic granites (Fujian BGMR, 1985; Guangdong BGMR, 1988; Guangxi BGMR, 1985; Hunan BGMR, 1988; Jiangxi BGMR, 1984; Zhejiang BGMR, 1989).

Although the tectonic evolution of the SCC has been addressed in many studies, the Early Paleozoic and the Early Mesozoic events are still debated. Some workers have correlated the Early Paleozoic event with the closure of the Paleo-Huanan Ocean along the Zhenghe–Dapu Fault, and the collision between Southeast Asia and SCC (Guo et al., 1989; Liu and Xu, 1994). However, recent studies indicate that the Early Paleozoic event is mostly intra-continental orogeny (e.g., Charvet, 2013; Charvet et al., 2010; Faure et al., 2009; Ren and Chen, 1989; Shu, 2006, 2012; Shu et al., 2008a, 2008b, 2011, 2014; Zhou et al., 2003). For the Early Mesozoic event, Hollway (1982) and Ren (1991) proposed the westward subduction of the Pacific Plate to have exerted the major control. Several recent studies have identified the Early Mesozoic orogen as a fold and thrust belt formed within intra-plate setting that was affected by the collision between North China

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and South China Cratons in the north, and Southeast Asia Block and South China Cratons in the south, respectively (Wang et al., 2007b; Zhang et al., 2011a; Zhou et al., 2006).

Granitoids provide important information on magma genesis and tectonic settings (Pearce et al., 1984; Pitcher, 1979, 1983). Several studies have reported the geochronological and geochemical features of granitic intrusions in the SCC (e.g., Deng et al., 2012; Li et al., 2010; Liu et al., 2010; Wang et al., 2012b; Xia et al., 2014; Xu et al., 2011; Yang et al., 2010). However, some of the granitic plutons within East China Block which help constrain the geological evolution of South China are short of precise geochronological and geochemical information. In order to obtain better insights into the evolution of the SCC, this study presents results from field geological investigations, zircon U–Pb geochronology, Lu–Hf isotopes and whole-rock geochemistry of six representative plutons from the SCC.

2. Geological background and features of petrology

The Jiangshan–Shaoxing–Pingxiang–Guanxian Fault is considered as the collisional suture zone (Fig. 1) between the Yangtze and Cathaysia blocks in Neoproterozoic (e.g., Charvet et al., 2010; Huang, 1978; Ren, 1991; Shu, 2006). Studies have demonstrated that the Yangtze and Cathaysia blocks have different stratigraphic units and sedimentary sequences (Shu, 2012; Zhao and Cawood, 2012). The Yangtze block preserves Neoarchean continental nucleus which is distributed sporadically around the Kangdian and Huangling areas (Shu, 2012). These rocks are involved within late Mesoproterozoic to early Neoproterozoic deformed belts, which are unconformably overlain by weakly metamorphosed Neoproterozoic strata (Zhao and Cawood, 2012). In the Jiangnan region of SE Yangtze block, the Neoproterozoic succession mainly consists of Pre-Nanhua basement (e.g., Lengjiaxi Group) covered by the Banxi Group or Nanhua Strata and Sinian Strata. The Banxi Group or Nanhua Strata is mainly composed of conglomerate, sandstone and the Sinian Strata mainly contains siliceous rocks, tillite, marl, limestone and shale intercalated with dolomite. The Cambrian strata include coal layer and carbonate rocks in which trilobites were well preserved. The Ordovician strata comprise flysch and carbonate rocks, with trilobites and gastropoda (*Sinoceras*). The Silurian system is represented by a set of rhythmic bedding composed of graptolite-bearing sandstone, siltstone and mudstone (e.g., Li et al., 2002; Shu et al., 2014; Zhang et al., 2011b).

In contrast, Paleoproterozoic rocks composed of granodiorite, granite and various clastic rocks formed between 1.7–1.9 Ga constitute the oldest rock in the Cathaysia block (Li, 1997; Yu et al., 2009), which is distributed primarily in the Wuyi domain. Due to lack of geochronological evidence, the Mesoproterozoic history remains unclear. However, Neoproterozoic rocks are widespread, mostly composed of marine volcanic rocks, greywacke and pelitic-arenaceous rocks. Most of the Neoproterozoic rocks experienced metamorphism and were converted to schist, gneiss, granitic gneiss or migmatite. The Nanhua System discordantly overlies the Pre-Nanhua strata. From the Nanhua to Ordovician, rhythmic pelitic-arenaceous rocks intercalated with carbonate rocks were deposited. The Silurian Strata is absent in this block. Subsequent to the orogeny and strong deformation in the late Early Paleozoic, the Yangtze and Cathaysia blocks were assembled into the unified depositional region, on which Late Paleozoic littoral–neritic sediments composed of carbonates intercalated with clastic material were accumulated (Shu et al., 2008b).

The Early Paleozoic and Early Mesozoic granitoids are exposed extensively in the SCC (Fig. 1) and occur mainly as batholiths with a dome shape and with massive texture and gneissic structure (Wang et al., 2011b, 2013b; Zhou et al., 2006, 2007). The massive granites are distributed towards the core of the plutons and the gneissic ones towards the margin. In the margin, foliation, stretching lineation, asymmetric porphyroclast and augen mineral fabrics are commonly developed. The six plutons studied in this paper, namely Yuechengling, Haiyangshan, Jinxi, Nanyue, Luxi and Qingzhou, are distributed in the Jiangnan and Cathaysia areas (Fig. 1). Most of these intrusions cover more than 100 km^2 area (Guangdong BGMR, 1988; Guangxi BGMR, 1985; Hunan BGMR, 1988; Jiangxi BGMR, 1984).

The Yuechengling, Haiyangshan, Jinxi and Qingzhou granites intruded into Cambrian, Ordovician, Sinian and lower Palaeozoic strata respectively (Fig. 2a, b and d). Most of these rocks are overlain unconformably by middle Devonian strata and show similar geological features. From core to margin of the plutons, an obvious zoning is seen with medium to coarse-grained massive granite, fine-grained massive

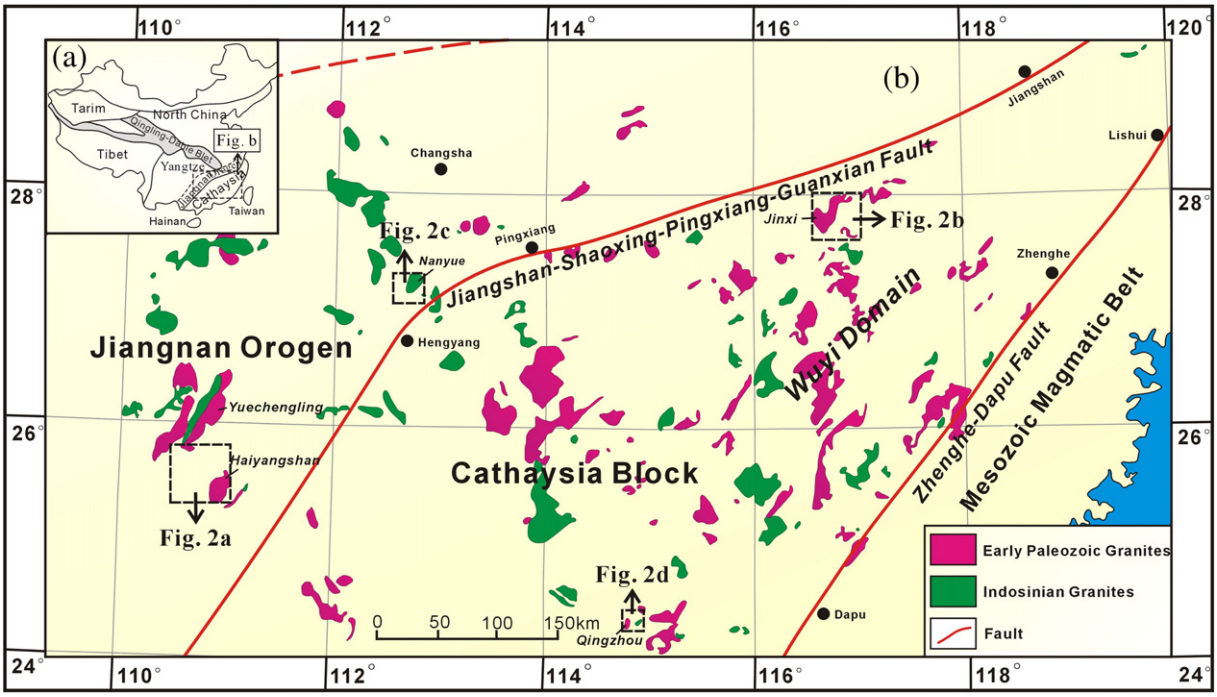

Fig. 1. (a) Tectonic outline of China. (b) Distribution of the Early Paleozoic and Early Mesozoic granites in the South China Craton.