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Origin of Silurian gabbros and I-type granites in central Fujian, SE China: Implications for the evolution of the early Paleozoic orogen of South China

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ABSTRACT

The early Paleozoic orogen of South China is possibly one of the few examples of intraplate orogeny in the world. It is characterized by an angular unconformity between post-Silurian cover and pre-Devonian strata and by the intensive and extensive early Paleozoic granitic plutonism. However, synchronous mafic–ultramafic rocks have not been well-studied, but they are crucial for understanding the nature and evolution of the orogen. In this paper, we present the first detailed LA-ICP-MS zircon U–Pb dating, major and trace element geochemical and Sr–Nd–Hf isotopic data for a Silurian gabbroic pluton (Dakang) and a coeval granitic pluton (Guiyang), that have recently been identified in central Fujian, in the southeastern part of the orogen. We assess the origin of these mafic and granitic rocks and their relationship to the evolution of the early Paleozoic orogen in South China. LA-ICP-MS zircon U–Pb dating shows that the Dakang and Guiyang plutons were emplaced at 441–438 Ma and 431 Ma, respectively. The Dakang pluton consists of gabbros and minor intermediate rocks (diorite, monzodiorite and monzonite). These rocks are all metaluminous and potassic, and are enriched in large ion lithophile elements (LILE) and depleted in high field strength elements (HFSE). They have initial $^{87}Sr/^{86}Sr$ of 0.7066–0.7098, ε_{Nd} (T) of −7.0 to −3.3 and ε_{Hf} (T) (in-situ zircon) of −5.2 to −4.4. Geochemical data suggest that the Dakang gabbroic magmas were derived by partial melting of previously subduction-modified lithospheric mantle in the spinel–garnet transition zone at a high temperature (~1300 °C). These primary magmas underwent fractionation crystallization of clinopyroxene and amphibole, forming the evolved gabbros and intermediate rocks. The Guiyang pluton consists of weakly peraluminous granites, which show low Ga/Al ratios ($10{,}000^{*}Ga/Al < 2.6$) and so can be classed as I-type granites. They have initial $^{87}Sr/^{86}Sr$ of 0.7095–0.7113, ε_{Nd} (T) of −6.7 to −5.9 and ε_{Hf} (T) (in-situ zircon) of −7.7 to −0.8. Geochemical data suggest that the Guiyang granites were generated by partial melting of a mixed source of Paleoproterozoic metaigneous and metasedimentary rocks in the lower crust. Our new data, together with published data, confirm that lithospheric delamination occurred along the metamorphic core of the early Paleozoic orogen of South China during the Silurian (442–420 Ma), and that this represents a post-orogenic tectonic regime in the orogen core.

1. Introduction

The early Paleozoic orogeny in South China was originally called "the Kwangsian movement" by Ting (1929) and generally been known as the Caledonian orogeny in Chinese literature. It is marked by an angular unconformity between post-Silurian cover and strongly deformed pre-Devonian strata with extensive and intensive granitic plutonism in South China (e.g., Huang et al., 1980; Ren, 1991). Despite decades of considerable research, there has been no consensus on the tectonic environment and geodynamic mechanism for formation of this orogen (see review in Li et al., 2010; Charvet, 2013). Two contrasting groups of models, i.e. collisional belt vs. intracontinental orogen, have been proposed. The former regards the early Paleozoic orogen as a result of continental collision by the closure of the so-called Nanhua Ocean between the Yangtze and Cathaysia blocks (e.g., Chen et al., 2006; Guo et al., 1989; Ma et al., 2004; Peng et al., 2006; Qin et al., 2013), whereas the latter considers the early Paleozoic orogen to be of an intraplate nature, which closed the Nanhua failed rift basin (e.g., Charvet et al., 2010; Faure et al., 2009; Huang et al., 2013; Li, 1998; Li et al., 2010; Shu et al., 2008; Wang et al., 2007, 2011; D. Wang et al., 2013; Wang et al., 2013a, 2013b; Yao et al., 2012). Although granites are widespread in the region and have received considerable attention, synchronous volcanics and mafic–ultramafic rocks, which are crucial for understanding the nature of the orogen, have been much less well-studied. Recently, Yao et al. (2012) have identified a Silurian (ca. 435 Ma) mafic-intermediate volcanic succession in northern Guangdong and suggested that these rocks were derived from the

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lithospheric mantle as a consequence of lithospheric delamination in a post-kinematic regime. Wang et al. (2013b) have reported geochronological and geochemical data for several Silurian (ca. 434–420 Ma) gabbroic plutons in northern and southern Guangdong and proposed that these gabbroic rocks were formed by partial melting of the paleosubduction-modified lithospheric mantle during post-orogenic collapse.

In this paper, we present the first detailed LA-ICP-MS zircon U–Pb dating, major and trace element geochemical and Sr–Nd–Hf isotopic data for a Silurian gabbroic pluton (Dakang) and a coeval granitic pluton (Guiyang) recently identified in central Fujian, and use them to explore the origin of these mafic and granitic rocks and their relationship to the evolution of the early Paleozoic orogen in South China.

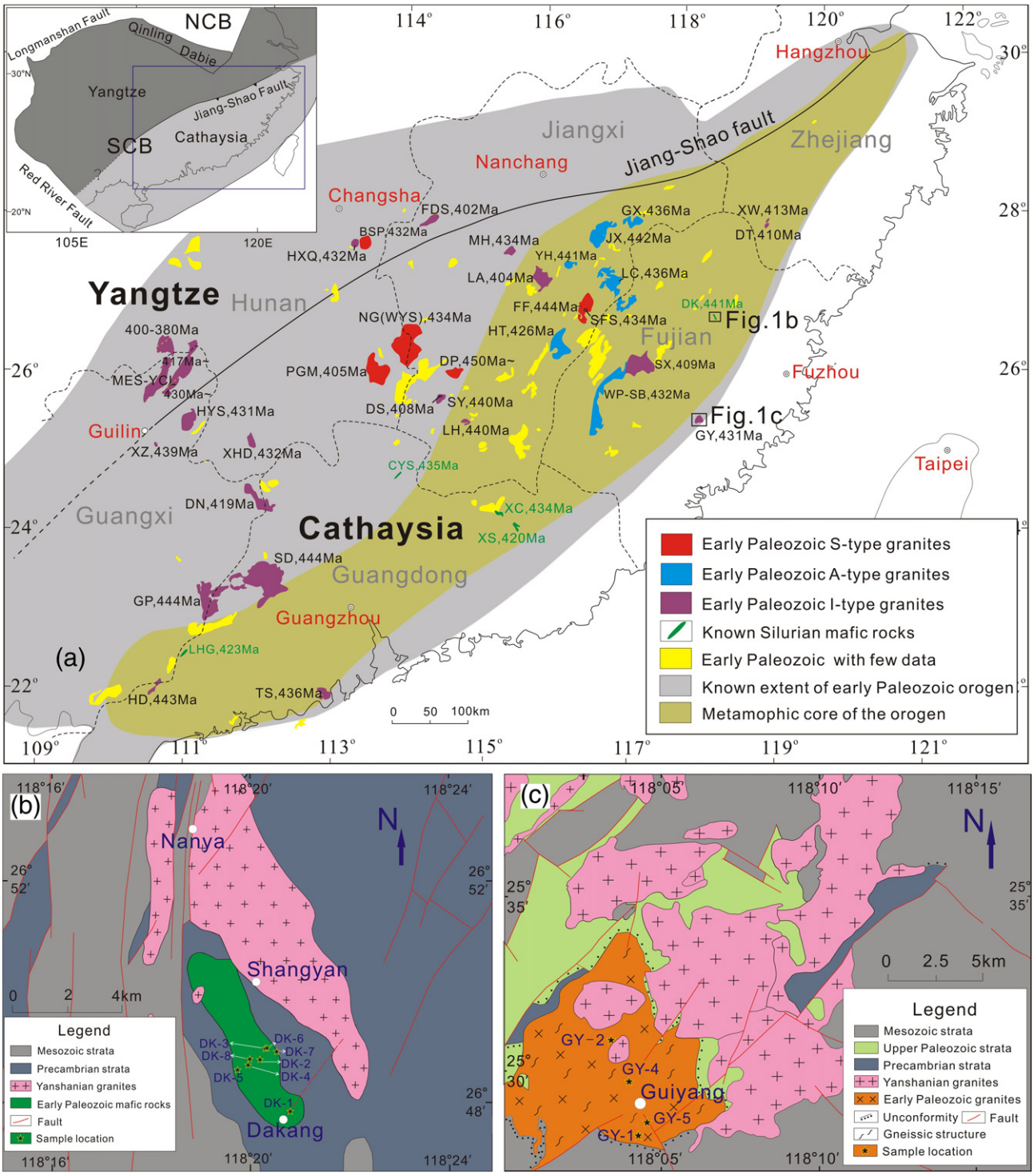

Fig. 1. (a) Sketch map showing the distribution of the Ordovician–Devonian magmatism in southeast China (modified from Li et al., 2010; Sun, 2006; Wang et al., 2011, 2013a; Yao et al., 2012). Also shown are the extent of the early Paleozoic orogen of South China and the field of the Metamorphic core of the orogen (Li et al., 2010). Data sources for the granites and mafic rocks see the Electronic Appendix C. (b) and (c) geological map of the Dakang and Guiyang plutons.