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Early Cretaceous potassic volcanic rocks in the Jiangnan Orogenic Belt, East China: Crustal melting in response to subduction of the Pacific–Izanagi ridge?

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ABSTRACT

Eastern China is characterized by widespread Mesozoic magmatism that was closely related to subduction of the Paleo-Pacific Plate, but the genetic relationship between magmatism and subduction is not always clear. The Jiangnan Orogenic Belt (JOB) is a Neoproterozoic collisional belt between the Yangtze and Cathaysian blocks. Early Cretaceous felsic magmas from the Tianmushan basin in the eastern JOB form a >3000 m thick volcanic sequence erupted within an extremely short period of time (132–130 Ma). These rocks are potassic (K_2O = 3.86–6.05%) and peraluminous (A/CNK = 1.0–1.23), and are compositionally similar to experimental melts derived from predominantly clay-poor and K-rich metasediments or granodiorites at crustal conditions. They are LILE- and LREE-enriched ($(La/Yb)_{CN}$ = 9.0–14.6) and display variable Eu anomalies and Nb–Ta depletion. The weakly variable and negative whole-rock $\varepsilon_{Nd}(t)$ (−5.4 to −2.5) and heterogeneous zircon $\varepsilon_{Hf}(t)$ values (−6.7 to +3.5) of these rocks are similar to those of basement rocks beneath the JOB, suggesting a genetic relationship with basement. No magmas with clear subduction-related composition occurred at this time in the area and the compositions of the potassic rocks more closely resemble high-temperature melts of extensively thinned crust in continental rift environments. Our data favors a model that the Early Cretaceous potassic magmas formed as subduction of the Pacific–Izanagi ridge resulted in upwelling asthenosphere, providing the high temperatures required to extensively melt the lower-middle crust in the eastern JOB.

1. Introduction

The eastern and southeastern part of the East Asian continent has been an active continental margin since the early Mesozoic (Maruyama et al., 1997; Li and Li, 2007; Sun et al., 2007). A number of Mesozoic events occurred in this region, such as the lithospheric destruction and thinning beneath the North China Craton and even all along the East Asian margin (e.g., Fan and Menzies, 1992; Menzies et al., 1993; Griffin et al., 1998; McKenzie and Priestley, 2008; Zhu et al., 2012), and the Cretaceous giant igneous event and large-scale mineralization (e.g., Zhou and Li, 2000; Wu et al., 2005; Li and Li, 2007; Sun et al., 2007; Yan et al., 2008; Tang et al., 2013; Yang et al., 2014). Although lithospheric thinning and large-scale magmatic activity in eastern China have widely been considered to be associated with subduction of the Paleo-Pacific Plate, the relationship between them remains unresolved. Some geologists invoked a lithospheric delamination model to interpret the removal of the cold and thick lithosphere beneath the North China Craton (Wu et al., 2002; Gao et al., 2008), and even in the lower Yangtze region (e.g., Xu et al., 2002, Wang et al., 2006, 2007a). In SE China, the origin of the Mesozoic igneous events and mineralization was attributed to flat-slab subduction and subsequent foundering of the subducting slab (Li and Li, 2007; Li et al., 2010, 2013), or else formed in a back-arc extensional tectonic setting (Yan et al., 2008; Liu et al., 2010; Jiang et al., 2011; Tang et al., 2013; Xie et al., 2011; Yang et al., 2014). Alternatively, some recent studies have proposed a genetic link between the Mesozoic magmatism and mineralization in East Asia related to a slab window coupled with ridge subduction (Sun et al., 2007, 2010; Ling et al., 2009, 2011; Li et al., 2011, 2012).

In eastern China, including the Jiangnan Orogenic Belt (JOB) and the Lower Yangtze River belt (LYRB) (Fig. 1a, b), most of the Early Cretaceous extrusive and intrusive felsic rocks are characterized by potassium-rich affinities (Wang et al., 2006). Generally, such potassic magmas are thought to form in extensional regimes and rarely occur in modern active subduction zones (Nelson, 1992). The main petrogenetic models for such magmatism include: (1) low-degree melting of enriched lithospheric mantle (e.g., Pe-piper et al., 2009; Nejbert et al., 2012); (2) differentiation of mantle-derived mafic magmas (e.g., Foley

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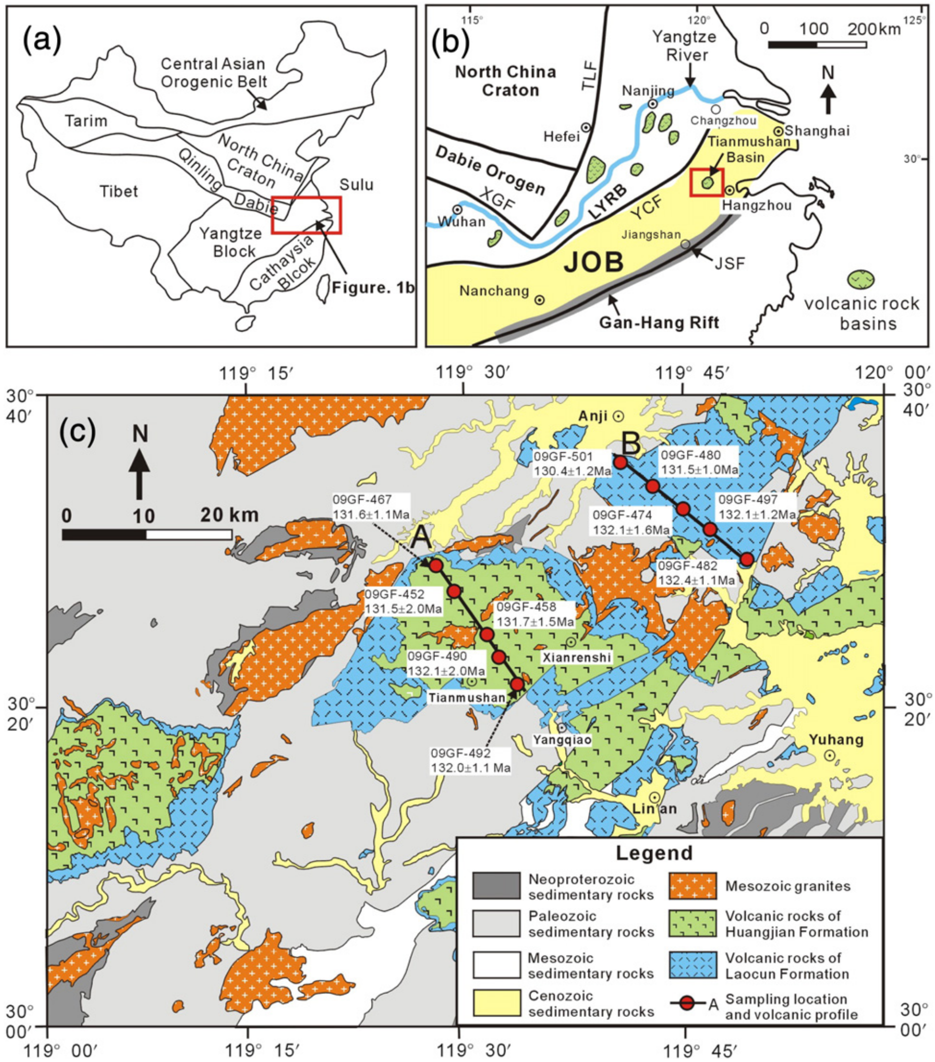

Fig. 1. (a) Schematic map showing major tectonic units of China; (b) distribution of the Early Cretaceous volcanic rock basins in southeastern China (modified after Wang et al., 2006 and Jiang et al., 2011), showing the location of the Jiangnan Orogenic Belt (JOB) and the Lower Yangtze River belt (LYRB), TLF = Tancheng–Lujiang Fault; JSF = Jiangshan–Shaoxing Fault; XGF = Xiangfan–Guangji Fault, YCF = Yangxin–Changzhou Fault; (c) geological map of the Tianmushan basin, showing the distribution of the Early Cretaceous volcanic and intrusive rocks (BGMRZJ, 1989). A, Xianrenshi Profile; B, Anji Profile (see text for details).

et al., 1987, Foley, 1992); and (3) crustal melting of K-rich protoliths (e.g., Wang et al., 2005; Kimura and Nagahashi, 2007; Long et al., 2015). However, the geodynamic association between the Mesozoic potassic magmatism in eastern China and the coeval subduction of the Paleo-Pacific Plate is poorly constrained at present.

The JOB, which extends from Zhejiang–Anhui provinces in the east to Jiangxi–Hunan–Guizhou–Guangxi provinces in the west (Fig. 1b), is one of the most important Mesozoic metallogenic- and magmatic-belts in eastern China (Gilder et al., 1991, 1996; Chen and Jahn, 1998). Most of the Mesozoic igneous rocks of the JOB show high-K calc-alkaline to shoshonitic affinities with relatively high Nd concentrations and more radiogenic Nd (typical $\varepsilon_{Nd}(t)$ between −8 and −4) than those felsic igneous rocks from the adjacent areas (typical $\varepsilon_{Nd}(t)$ between −15 and −12) (Gilder et al., 1996). In this paper, we present high-precision zircon U–Pb ages and Hf isotopic compositions and whole-rock geochemical data from an Early Cretaceous felsic potassic volcanic suite from the Tianmushan basin in the eastern JOB. We also provide one-dimensional numerical crustal melting modeling results. These data enable us to determine precisely the volcanic eruption and provide important information regarding the role of subduction of the Paleo-Pacific Plate in the genesis of the potassic magmatism.

2. Geological background and sample descriptions

South China consists of the Yangtze Block in the northwest and the Cathaysian Block in the southeast, which were amalgamated during the Neoproterozoic along the Jiangshan–Shaoxing fault (Li et al., 2009a). The JOB is considered to represent the Neoproterozoic collisional belt between the Yangtze and Cathaysian blocks. It is bordered by the Jiangshan–Shaoxing fault in the southeast and by the Yangxin–Changzhou fault in the north (Fig. 1b). The tectonic evolution of the JOB can be summarized as follows: (1) Following the collision between the Yangtze and Cathaysian blocks, Neoproterozoic rifting in response to the breakup of Rodinia led to emplacement of voluminous mafic and felsic magmas, deposition of deep-sea sediments, and regional medium-grade metamorphism (e.g., Li et al., 2002, 2009a; Wang et al., 2007b; Zheng et al., 2008); (2) Early Paleozoic intracontinental deformation and emplacement of peraluminous granitoids resulted from the breakup of the East Gondwanaland (Charvet et al., 2010; Wang et al., 2013); (3) There was widespread deposition of Late Paleozoic marine sediments; and (4) Widespread Mesozoic crustal deformation, magmatism, metamorphism and mineralization possibly resulted from subduction of the Paleo-Pacific Plate (e.g., Zhou and Li, 2000; Li