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2090–2070 Ma A-type granitoids in Zanhuang Complex: Further evidence on a Paleoproterozoic rift-related tectonic regime in the Trans-North China Orogen

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ABSTRACT

The Xuting pluton, located at the north section of the Zanhuang Complex, contains potassic and sodic granite in both of which shallow level emplacement is shown by graphic texture feldspar and quartz intergrowth. Two potassic granite and one sodic granite samples yielded zircon $^{207}Pb/^{206}Pb$ ages of 2066 ± 17 Ma, 2092 ± 14 Ma, and 2071 ± 14 Ma, respectively, suggesting that the Xuting pluton emplaced between 2070 Ma and 2090 Ma, which is coeval with the Paleoproterozoic Gantaohe Group dominated by mafic volcanic and sedimentary rocks. The potassic granite is enriched in SiO_2, total FeO, REEs (except Eu), Zr, Nb, Ga and Y, and depleted in MgO, CaO, Al_2O_3, Sr, V, Cr and Ni, with high TFeO/MgO ratios, consistent with the features of A-type granite. Except for the high MgO and low K_2O contents, the sodic granite also presents most of the features of A-type granites. The zircon saturation temperatures from the potassic and sodic granites range from 855 to 998 °C and 853 to 933 °C respectively, indicating that they are from the high temperature magma. The potassic granites have the $\varepsilon_{Hf}(t)$ ranging from −5.9 to +1.33 and Hf model ages of 2.5–2.8 Ga, which are identical with the ages of Neoarchean TTG gneisses in the Zanhuang Complex. We propose that the potassic granite in the Xuting pluton derived from the partial melting of Neoarchean TTG gneisses. The sodic granites also present negative $\varepsilon_{Hf}(t)$ values from −4.81 to −0.76 and Hf model ages of 2.5–2.8 Ga, suggesting that they come from the partial melting of the Neoarchean crust. However, with relative enrichment in MgO and total FeO, and lower K_2O and Rb, the sodic granite was derived from a mafic source in the lower crust. The likely heat source was high heatflow associated with mantle upwelling. The A-type Xuting pluton and mafic volcanic rocks in the Gantaohe Group constitute a bimodal lithologic association from a Paleoproterozoic continental rift environment. 2.2–2.0 Ga magmas are widely distributed along the Trans-North China Orogen (TNCO), and also present a bimodal character. We propose that 2.2–2.0 Ga bimodal magmas throughout the TNCO were likely formed in a Paleoproterozoic rifting setting. Considering the widespread 2.2–2.0 Ga magmatic rocks in the North China Craton (NCC), we infer that the magmatism likely occurs in tensional environment after the initial amalgamation of the NCC in the late Archean.

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1. Introduction

The history of the NCC stretches back to ~3.8 Ga and has experienced a very complicated early Precambrian evolution. The general consensus is that the NCC achieved ultimate cratonization via the welding of several micro-continental blocks by collision (the "Lüliang Movement") in the late Paleoproterozoic (Wu et al., 1998; Zhai and Santosh, 2011, 2013; Zhao and Zhai, 2013; Zhao et al., 2012). There are, however, three different interpretations of the evolutionary process leading to this cratonization. The first model considers the NCC to be composed of five or seven micro-blocks that amalgamated by arc–continent or continent–continent collision at ca. 2.5 Ga (Fig. 1a, b; Wu et al., 1998; Zhai and Santosh, 2011) that was followed by Paleoproterozoic (ca. 2.35) rifting and younger subduction–accretion–collision processes leading to the final stabilization of the NCC at ~1.82 Ga (Zhai and Santosh, 2011). The second model divides the NCC into an Eastern Block (EB), a Western Block (WB) and a Central Orogenic Belt (COB) (Fig. 1c; Kusky and Li, 2003; Kusky et al., 2007; Li and Kusky, 2007;

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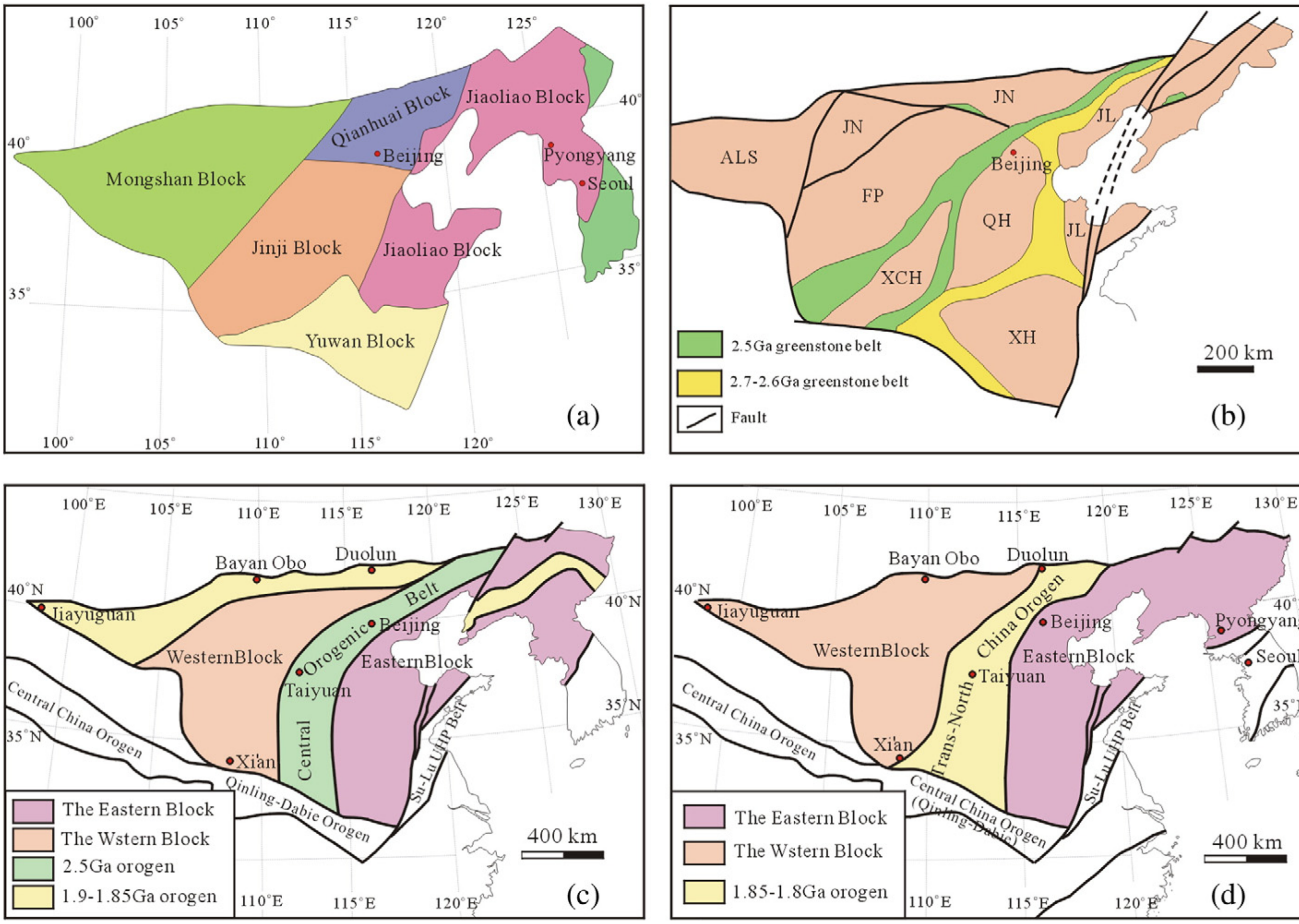

Fig. 1. Different division models on the North China Craton.
a after Wu et al., 1998; b after Zhai and Santosh, 2011; c after Kusky et al., 2007; d after Zhao et al., 2005.

Polat et al., 2005). Westward EB subduction beneath the WB welded the two blocks together in late Neoarchean (~2.5 Ga), which was followed by a series of rifts within the COB in the early Paleoproterozoic (2.5–2.4 Ga). The cratonization of North China was completed via the collision with unknown blocks (Baltic and Amazonian cratons?) along the Inner Mongolia–North Hebei Orogen in the late Paleoproterozoic (Kusky and Li, 2003; Kusky et al., 2007; Li and Kusky, 2007). The third and presently most popular model invokes the same three major divisions on the NCC, referring to them as the Eastern Block (EB), Western Block (WB) and the Trans-North China Orogen (TNCO) (Fig. 1d; Zhao et al., 1999a, 1999b, 2000a, 2000b). In this model, the WB initially eastward subducted toward the EB in the late Archean collision occurred at 1.85–1.8 Ga (the Lüliang Movement), leading to final stabilization of the NCC (Kröner et al., 2005a, 2005b, 2006; Wilde et al., 2005; Zhao and Cawood, 2012; Zhao and Zhai, 2013; Zhao et al., 1999a, 1999b, 2000a, 2000b, 2005, 2010). Zhao et al. (2005) further divided the WB into the Ordos Block, Yinshan Block and Paleoproterozoic Khondalite Belt, and identified the Jiao–Liao–Ji belt in the EB. In the above models, one of the key controversies concerns the geological processes along the TNCO/COB during the Paleoproterozoic (2.5–1.85 Ga) (Kusky and Li, 2003; Li and Kusky, 2007; Zhai and Liu, 2003; Zhai and Santosh, 2011; Zhao et al., 2001, 2005, 2010, 2012). Accordingly, improved constraints on Paleoproterozoic tectonothermal events in this belt are vital for resolving the overall evolution of the NCC.

Zircon U–Pb ages reveal that the NCC Paleoproterozoic magmatism occurred in three stages at 2.4–2.3 Ga, 2.2–2.0 Ga, and 1.95–1.8 Ga in the NCC (Wan et al., 2006; Wang et al., 2005). There is consensus that the 1.95–1.8 Ga magmatism was related to final cratonization of the NCC (Geng et al., 2004, 2006; Wan et al., 2006; Wang et al., 2005; Zhao et al., 2008a) and coeval with widespread metamorphism (Peng et al., 2014). 2.4–2.3 Ga magmas occur only sporadically in the southern margin of the North China Craton, at localities such as Dengfeng, Taihua, Xiaoqinling, and Zhongtiao (Diwu et al., 2007, 2014; Huang et al., 2012, 2013; Jiang et al., 2011; Sun et al., 1991; Yu et al., 2013), and in the central TNCO at Lüliang and Hengshan (Geng et al., 2006; Kröner et al., 2005b; Zhao et al., 2008a), and at Daqingshan in Inner Mongolia (Dong et al., 2007). In contrast, 2.2–2.0 Ga zircon U–Pb ages have commonly been recorded from volcanic and plutonic rocks (including mafic dykes) in the TNCO and the Jiao–Liao–Ji Belt (Fig. 2, Table S1 and references therein). Contemporary granitoids and mafic dykes have also been identified in the EB and WB (Fig. 2, Table S1 and references therein). The petrogenesis and tectonic setting of 2.2–2.0 Ga TNCO magmatism have not yet been fully resolved. Some workers favour a ~2.1 Ga collisional orogen within the TNCO before the 1.85–1.8 Ga orogenic event (Deng et al., 2014; Faure et al., 2007; Liu et al., 2005; Trap et al., 2008, 2009, 2012; Wang et al., 2010) whereas others argue that the 2.2–2.0 Ga magmatism was more likely rift-related in this belt (Du et al., 2009, 2010, 2012; Geng et al., 2003; Peng et al., 2012; Sun et al., 1991; Wang et al., 2014a; Xie et al., 2012; Yang et al., 2011a; Yu et al., 1997; Zhao et al., 2011; Zhou et al., 2014, 2015). Finally, it has also been proposed that the Paleoproterozoic magmatism in the TNCO was generated entirely by a long-lived subduction process (Liu et al., 2012a, 2014a, 2014b; Zhao et al., 2008a). In this paper, we focus on the Xuting pluton of the Zanhuang Complex which contains 2070–2090 Ma potassic and sodic A-type granites and present new petrological, geochemical, zircon U–Pb geochronological and Lu–Hf

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