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The petrogenesis and tectonic implications of the granitoid gneisses from Xingxingxia in the eastern segment of Central Tianshan

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ABSTRACT

As part of Central Asian Orogenic Belt (CAOB), the Central Tianshan zone plays a crucial role in the reconstruction of the tectonic evolution of the CAOB. Furthermore, it is bordered by the Tarim Craton to the south, and the comparable evolutionary history between them enables the Central Tianshan zone to provide essential information on the crustal evolution of the Tarim Craton. The eastern segment of the Central Tianshan tectonic zone is characterized by the presence of numerous Precambrian metamorphic rocks, among which the Xingxingxia Group is the most representative one. The granitoids gneisses, intruded into the Xingxingxia Group, consist of two major lithological assemblages: (1) biotite-monzonitic gneisses and (2) biotite-plagioclase gneisses. These metamorphosed granitoid rocks are characterized by enrichment in SiO_2, Al_2O_3 and K_2O and depletion in MgO and FeO_T. The Rittmann index (σ) spreads between 1.44 and 2.21 and ACNK ($Al_2O_3/(CaO + Na_2O + K_2O)$) ranges from 1.03 to 1.08, indicating that these granitoid gneisses are high-K calc-alkaline and peraluminous. Trace element data indicate that the studied samples are enriched in LREE with moderate REE fractionated patterns ($(La/Yb)_N$ = 10.5–75.3). The concentrations of HREE of the garnet-bearing gneisses are significantly higher than those of garnet-free gneisses. The former show pronounced negative Eu anomalies (Eu/Eu^* = 0.32–0.57), while the latter are characterized by negligible negative Eu anomalies to moderate positive Eu anomalies (Eu/Eu^* = 0.80–1.35). In addition, the enrichment of LILE (Rb, Th, K, Pb) and depletion of HFSE (Ta, Nb, P, Ti) of the examined granitoid gneisses are similar to typical volcanic-arc granites. Zircons U–Pb dating on the biotite monzonitic gneiss yields a weighted mean $^{206}Pb/^{238}U$ age of 942.4 ± 5.1 Ma, suggesting their protoliths were formed in the early Neoproterozoic, which is compatible with the time of the assembly of supercontinent Rodinia. The zircons have a large $\varepsilon_{Hf}(t)$ variation from −5.6 to +3.2, suggesting that both old crust-derived magmas and mantle-derived juvenile materials contributed to the formation of their protoliths. Based on field observation, and petrological, geochemical and geochronological investigations, we infer that the granitoid gneisses from Xingxingxia were probably formed on a continental arc that resulted from the interaction of Australia and the Tarim Craton during the assembly of the Rodinia supercontinent, and that the Central Tianshan zone was a part of the Tarim Craton during that time. Besides, the Grenvillian orogenic events may have developed better in the Tarim Craton than previously expected.

1. Introduction

The Tianshan, resulted from polyphase accretion and deformation, is the longest mountain range in Central Asia. The Chinese Tianshan belt is divided into North Tianshan, Central Tianshan and South Tianshan by large-scaled faults. The Central Tianshan tectonic zone is a narrow domain between the early Paleozoic South Tianshan passive continental margin and the late Paleozoic North Tianshan arc zone (Liu et al., 2004), with the Precambrian rocks widely exposed and well preserved in the easternmost of the zone. However, most of the basement rocks are unconformably overlain by unmetamorphosed Paleozoic–Mesozoic sedimentary cover with only sporadic outcrops (Liu et al., 2004; Zhang et al.,

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2004; Li et al., 2005, 2009). The representative basement rocks which outcrop in Jianshanzi uplift and Tianhu sag are defined as Xingxingxia Group and Tianhu Group, respectively (Toby, 1997; Hu et al., 2006a,b, 2007). Granitoid intrusions with varying ages are widely distributed in these basement rocks, and most of them have crystallization age of 960–910 Ma (Hu et al., 2010).

Rocks of the Xingxingxia Group used to be considered as the oldest rocks in the Eastern Tianshan Mountains (Hu et al., 1986, 2001, 2006; Toby, 1997; Li et al., 1999, 2003; Liu et al., 2004), zircon SHRIMP U–Pb ages of the granodioritic gneisses, which belong to the Xingxingxia group, indicate that they crystallized at 1.4 Ga and subsequently underwent a 0.9–1.1 Ga tectono-thermal event, resulting in the intrusion of some migmatites and granitoid gneisses (Hu et al., 1986, 2006). Previous studies have been carried out on the early Precambrian evolution of the Eastern Tianshan (Hu et al., 1986, 2010; Gu et al., 1990; Xiu et al., 2002; Liu et al., 2004; Zhang et al., 2004, 2005; Song et al., 2013), and provided important information on the crystallization and metamorphism ages of these granitoid intrusions. The whole-rock Rb–Sr data yielded the age of 913.8 ± 4.5 Ma for the gneissic granite, interpreted as the emplacement age (Gu et al., 1990). The zircon SHRIMP U–Pb age, 942 ± 7 Ma, of the augen gneissic granite in the Xingxingxia Mountain, was interpreted as the crystallization age of the granite body (Hu et al., 2010). Granodioritic gneiss, intruded into the Xingxingxia Group, yielded a zircon U–Pb upper intercept age of 1218 ± 17 Ma, representing the magma crystalline age (Liu et al.,

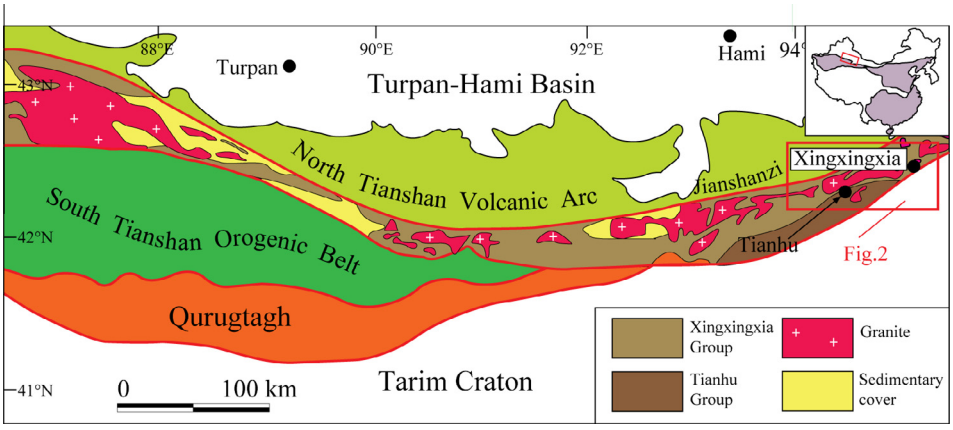

Fig. 1. Simplified tectonic map of the Eastern Tianshan region (after Li et al. (2003)).

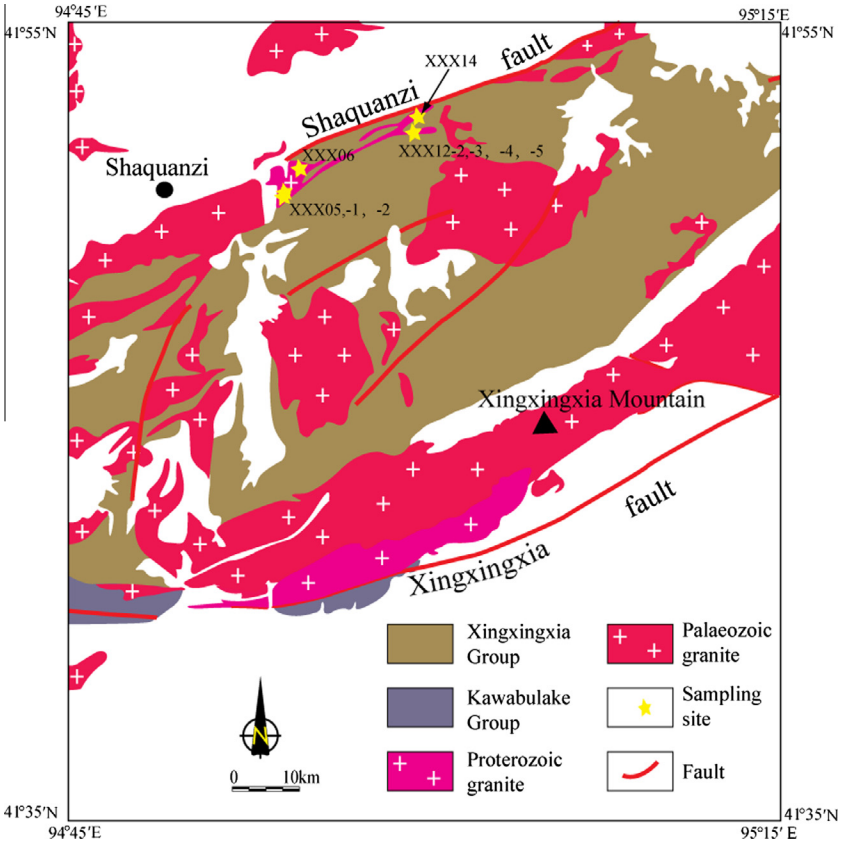

Fig. 2. Simplified geological map of the Xingxingxia area, Eastern Tianshan Mountains (modified after the geological map of Xingxingxia and Anxi, 1:200,000).