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Neoproterozoic granitic gneisses in the Chinese Central Tianshan Block: Implications for tectonic affinity and Precambrian crustal evolution

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ABSTRACT

The Chinese Tianshan is the southernmost orogenic terrane located in the long-lived accretionary Central Asian Orogenic Belt. Granitoid rocks are extensively exposed in the Chinese Tianshan, especially in its central part, known as the Chinese Central Tianshan Block (CTB) and therefore recorded the formation of continental crust. However, the tectonic affinity and crustal evolution of the CTB are still controversial. In order to better constrain the tectono-metamorphic evolution of the CTB, whole-rock geochemistry, zircon ages and Hf-in-zircon isotopic data are presented for augen- and banded granitic gneisses collected from a Precambrian basement terrane near the town of Baluntai. Zircon dating revealed two concordant Neoproterozoic age groups at 930–902 and 806 Ma for the augen- and banded gneisses, respectively. These rocks have high Al_2O_3 and K_2O, low CaO and Na_2O contents, and thus exhibit high aluminum saturation index (ASI) (1.09–2.05). They are enriched in light rare earth elements (LREE), display relatively flat heavy rare earth element (HREE) patterns with negative Eu anomalies, and are characterized by pronounced depletions in Nb, Ta, Ti and Sr and strong positive Pb anomalies. Zircons with ages at 930 Ma and 806 Ma yielded highly variable $\varepsilon_{Hf}(t)$ values from −10.87 to 0. Together with their relatively old crustal model ages (2473–1523 Ma) and the existence of Mesoproterozoic to Neoproterozoic inherited zircons (1411–883 Ma), the geochemistry indicates a crustal source dominated by metapelite and graywacke. Therefore, these gneisses were most likely produced by partial melting of metasedimentary rocks of the Precambrian CTB basement. Based on our and published age data, we suggest that the CTB basement experienced five episodes of Meso- to Neoproterozoic magmatism at 1458–1400, 969–926, 945–880, 806 and 740–707 Ma. Inherited zircon cores yielded $^{207}Pb/^{206}Pb$ ages at 1617–984 Ma, with positive initial $\varepsilon_{Hf}(t)$ values (+0.50 to +10.1), suggest early crustal growth from an isotopically primitive source during the Mesoproterozoic. In contrast, magmatic Neoproterozoic zircons from granite-gneisses giving $^{206}Pb/^{238}U$ ages at 957–737 Ma show evolved $\varepsilon_{Hf}(t)$ values (mostly between −7 and +4), overlapping the crustal evolution trend defined by the inherited zircon cores and thus indicating that crustal reworking occurred in the Neoproterozoic. The Precambrian evolutionary history of the CTB is similar to that of the adjacent Yili Block (YB), suggesting that the two terranes constitute a single crustal unit until in the Precambrian. Significant age and isotopic differences between the combined CTB/YB terrane suggest that it is unlikely to have rifted off the Tarim Craton.

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1. Introduction

The Central Asian Orogenic Belt (CAOB), separated by the Siberian Craton to the north and the Tarim and North China Cratons to the south (Fig. 1), is one of the largest Phanerozoic accretionary orogenic belts on Earth (Sengör et al., 1993). It was formed by continuous accretions of different terranes, such as island arcs, seamounts, oceanic plateaux and microcontinents (Jahn et al., 2000, 2004; Xiao et al., 2004; Windley et al., 2007). Several Precambrian continental blocks (e.g. the Chinese Cental Tianshan Block, Yili Block, Ishim-Middle Tianshan in Kyrgyzstan, Aktau-Junggar in Kazakhstan, see Fig. 1 in Kröner et al., 2012) have been incorporated

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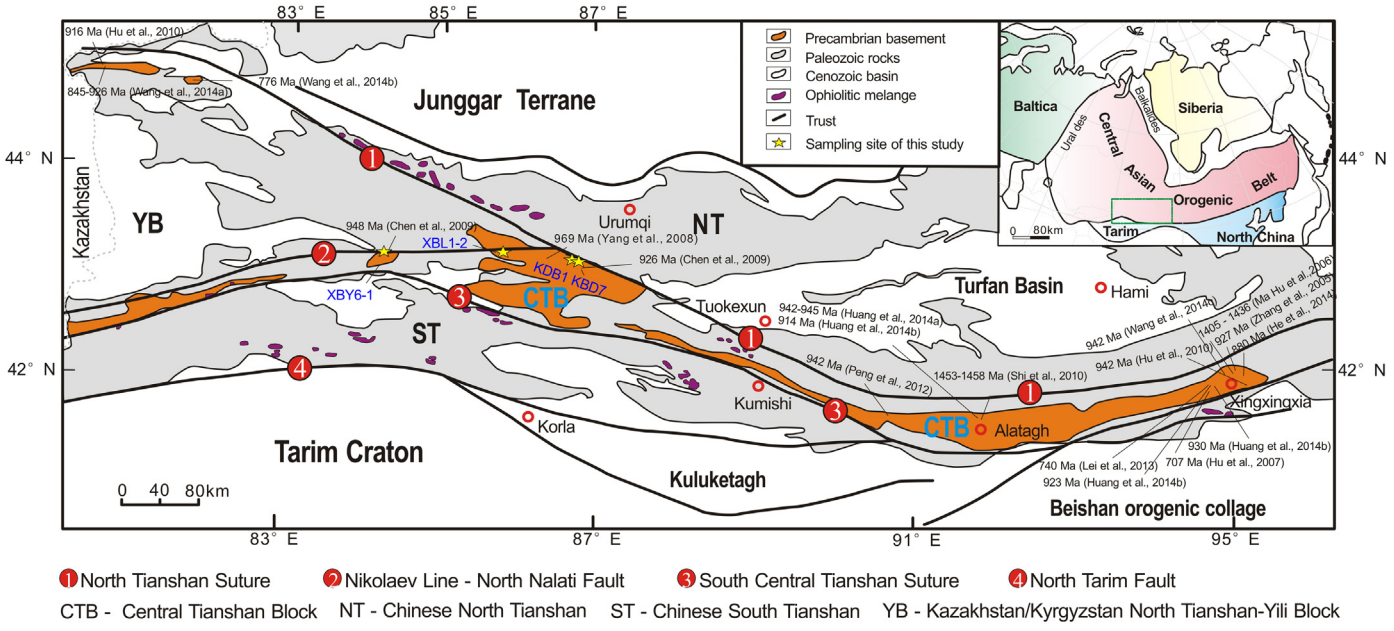

Fig. 1. Simplified geological map of the Chinese Tianshan showing main tectonic boundaries and distribution of Precambrian rocks (modified after Xiao et al., 2004; Gao et al., 2009). Inset is a simplified map of the Central Asian Orogenic Belt (modified after Xiao et al., 2010).

into the CAOB during its accretionary history. These Precambrian basement terranes are of importance in understanding the tectonic evolution of the CAOB (Kröner et al., 2014). Although the similarities of late Neoproterozoic–Cambrian cover sequences on these blocks have been studied, their tectonic affinities have so far been poorly constrained (Windley et al., 2007; Levashova et al., 2011). All these microcontinents dispersed within the CAOB are commonly considered to have rifted from an old continent. Four cratons, namely the Tarim Craton (Levashova et al., 2009, 2011; Lei et al., 2011, 2013; Shu et al., 2011; Rojas-Agramonte et al., 2011; Ma et al., 2012a, 2012b, 2013; Liu et al., 2014; Wang et al., 2014c), the Siberian Craton (Sengör and Natal'in, 1996; Turkina et al., 2007), the Eastern European Craton (Baltic shield) (He et al., 2012, 2014; Huang et al., 2014a, 2014b), and Northern Gondwana (Dobretsov et al., 2003) were argued to be the best choice for such an old continent.

The Chinese E-W-trending Tianshan (Fig. 1) is a huge Paleozoic orogenic belt in the southern CAOB and extends from Uzbekistan in the west to Xinjiang Uygur Autonomous Region of China in the east (Charvet et al., 2007; Alexeiev et al., 2015). The Chinese Tianshan consists of several tectonic units (Windley et al., 1990; Carroll et al., 1995; Gao et al., 1998; Shu et al., 2004, 2011; Xiao et al., 2010), and some of these, namely, the Chinese Central Tianshan Block (CTB) and Yili Block (YB) are considered as old crustal segments with Precambrian basement (Hu et al., 2000; Liu et al., 2004; Xiao et al., 2004, 2008; Ma et al., 2012b, 2013; Huang et al., 2014a; Wang et al., 2014a). Some authors suggested that the CTB was rifted-off from the Tarim Craton (Gao et al., 1998, 2009; Shu et al., 2004, 2013; Lei et al., 2011, 2013; Rojas-Agramonte et al., 2014; Ma et al., 2012a, 2012b, 2013; Wang et al., 2014c), whereas He et al. (2012, 2014) and Huang et al. (2014a, 2014b) considered that there were no close relationships between the CTB and the Tarim Craton in terms of absence of Neoarchean crustal basement and 2000–1800 Ma metamorphism in the CTB. Thus, they argued that the East European Craton (Baltica) may have been the origin of the CTB due to similarities of Meosoproterozoic to early Neoproterozoic age populations and crustal growth at 1500–1400 Ma. Some recent studies, however, suggested that the CTB was an independent continental terrane with no affinities to any either of these old blocks (Hu et al., 2000; Liu et al., 2004; Li et al., 2009). More recently, the CTB was argued to be once a part of the Kazakhstan continent (area from Junggar basin to the Yili Block and contained the vast region of Kazakhstan continent and Kazakhstan/Kyrgyzstan Tianshan) (Xiao et al., 1992, 2008; Xu et al., 2003; Rojas-Agramonte et al., 2014). Conversely, Allen et al. (1992) and Qian et al. (2009) assumed that the CTB was the eastern part of the Yili Block. Therefore, the tectonic affinity of the CTB still remains controversial, and this has hampered the reconstruction of the Precambrian evolution of the Chinese Tianshan.

The key to unravel the tectonic affinity of the CTB lies in the spatial-temporal distribution of Precambrian basement and the history of crustal evolution. Although recent geochronological and geochemical data have improved the reconstruction of the Precambrian history of the CTB, its formation and evolution are still poorly constrained. The oldest magmatic rocks in the western and eastern parts of the CTB were suggested to have formed at 2466 Ma and 1458 Ma, respectively (Yang et al., 2008; Wang et al., 2014d), but it remains uncertain whether the Archean to Mesoproterozoic basement is widely exposed or only occurs locally. We present new whole-rock geochemical data, U–Pb zircon ages and Hf-in-zircon isotopic data for Neoproterozoic granitic basement rocks. The results provide constraints not only on the formation of the basement but also on the Precambrian crustal evolution of the CTB, which therefore shed light on its tectonic affinity and the Precambrian evolution of the CAOB.

2. Geological background

The Tianshan Orogenic Belt in China is located in a triangular zone in the southernmost CAOB and is bordered by the Tarim Craton in the south, the Junggar Terrane in the north and the Kazakhstan/Kyrgyzstan Tianshan in the west (Fig. 1). This belt resulted from Paleozoic subduction of the Paleo-Asian Ocean and accretions of several microcontinents. The belt is divided into the Chinese North Tianshan (NT), the Kazakhstan/Kyrgyzstan North Tianshan-Yili Block (YB), the Chinese Central Tianshan Block (CTB) and the Chinese South Tianshan (ST) (Fig. 1) (Gao et al., 2009; Qian et al., 2009; Long et al., 2011a). These domains are separated by the North

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