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Precambrian tectonic evolution of the Tarim Block, NW China: New geochronological insights from the Quruqtagh domain

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ABSTRACT

The Tarim Block is an important tectonic unit to understand the Proterozoic tectonic framework of the Central Asian Orogenic Belt and the supercontinent Rodinia. The granitic, dioritic, gabbroic intrusive rocks and volcanic–volcanoclastic rocks are widely distributed in the Quruqtagh domain of NE-Tarim. The precise ages of these rocks and their tectonic implications in this part of the world are not well understood. This paper reports geochronological data of gabbro, diorite and granitic rocks from Quruqtagh. LA ICPMS U–Pb zircon ages suggest that numerous of gabbroic and granitic rocks were mainly crystallized at ca. 800 Ma. New geochronological data from the magmatic zircons of gabbro, granite and paragneiss can be preliminarily divided into four groups, which are (1) 2469 ± 12 Ma or 2470 ± 24 Ma, (2) 933 ± 11 Ma to 1048 ± 19 Ma, (3) 806 ± 8 Ma, 798 ± 7 Ma, 799 ± 24 Ma, 698 ± 51 Ma (lower intercept age of the paragneiss), and (4) 1930 Ma (upper intercept age of the paragneiss), respectively. These age data are consistent with four tectono-thermal events that took ever place in the Tarim Block. The 93 U–Pb age data (seven for average Concordia age from seven igneous plutons, 86 for xenocrystic and metamorphic ones) from eight samples can be divided into four evolutionary stages: 2360–2550 Ma (peak of 2510 Ma), 1800–2020 Ma (peak of 1870 Ma), 860–1140 Ma (peak of 920 Ma) and 680–840 Ma (peak of 800 Ma), respectively. The age peak of 2500 Ma, consistent with characteristic period of a global building-continent event, indicates that the late Neoarchean–early Paleoproterozoic magmatism had been ever taken place in Tarim. Two peaks at 1870 Ma and 920 Ma, being two assembly periods of the middle Paleoproterozoic Columbia and the Neoproterozoic Rodinia supercontinents, suggest that Tarim had connections with both Columbia and Rodinia, whereas structural evidence of these two events is absent in Tarim. Notable peak of 800 Ma is interpreted as a response to the break-up of Rodinia supercontinent. The geological indicators of break-up such as Neoproterozoic granite, bimodal igneous rocks, composite magmatic flow, basic dyke swarm and continental rift type basins are well developed, followed by a large-scale of late Neoproterozoic glacier event. Four stages of magmatism mentioned above constitute major events in the Precambrian evolution of Tarim and Central Asian. These data, combining with previous U–Pb ages from igneous rocks, provide a significant line of evidence for understanding the Rodinia evolution of Tarim and the relationships with South China, east India and east Antarctica, Lesser and Great Himalaya blocks in Proterozoic. A primary reconstruction of the Tarim Block, connecting it with South China, east India and east Antarctica, Lesser and Great Himalaya blocks, is finally proposed.

1. Introduction

The Tarim Block is located in the southern part of the Central Asian Orogenic Belt (CAOB in short) that suffered from multiple accretionary orogenesis and episodic growth of continents including the early Paleozoic subduction–accretion, the Carboniferous arc and the early–middle Permian post-orogenic rifting and strike-slip shearing (Allen et al., 1993; Carroll et al., 1995; Matte et al., 1996; Mattern and Schneider, 2000; Li et al., 2003a; Charvet et al., 2007; Xiao et al., 2002, 2003; Xiao and Kusky, 2009; de Jong et al., 2006, 2009; Pirajno et al., 2008). Recently, de Jong et al. (2006a) reported the $^{40}Ar/^{39}Ar$ plateau ages of 453 ± 2 Ma and 449 ± 2 Ma for phengite grains from quartzite mylonites from the blueschist facies Ondor Sum accretion complex in Inner Mongolia, suggesting that an early Paleozoic geodynamic process fringed by subduction–accretion complexes and island-arcs occurred in the NE margin of Condwana. Wang et al. (2010) obtained 341 ± 6 Ma and 338 ± 8 Ma LA ICPMS zircon U–Pb ages from granites in the Chinese NW-Tianshan, and 323 ± 1 Ma and 316 ± 2 Ma $^{40}Ar/^{39}Ar$ plateau ages for muscovite grains from blueschist from the Chinese SW-Tianshan; the first two ages were interpreted as the peak age of

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the Yili igneous arc, and the last two ages imply an accretion–orogeny during late Carboniferous. The high-K-granitic samples from the Yili area (NW-Tianshan) yielded LA ICPMS zircon U–Pb ages of 294 ± 7 Ma, 273 ± 6 Ma and 285 ± 7 Ma (Wang et al., 2009); the biotite sample from the early Carboniferous granite in the Yili arc's southern margin, gave a 263 ± 1 Ma $^{40}Ar/^{39}Ar$ plateau age, and the muscovite and biotite grains from two pre-Carboniferous meta-sediments in the Yili arc's basement yielded plateau ages of 253 ± 1 Ma and 252 ± 1 Ma (de Jong et al., 2009), these six ages were considered as the timing of the post-collision or the continental rifting.

Tarim is separated from the Tianshan Paleozoic Orogenic Belt to the north by the Southern Tianshan Fault and from the Kunlun Paleozoic Orogenic Belt to the south by the Western Kunlun Fault (Fig. 1). It is considered as one of three Chinese cratons and records the early crustal evolutionary history of NW China and its adjacent areas (Lu et al., 2008).

The Tarim Block covers an area of 550,000 km^2 and its major part (more than 80%) is occupied by Cenozoic desert. This block was affected by Permian rift-type bimodal volcanism (mafic dykes, ultramafic rocks) and intruded by syenite, nepheline syenite, aegirine syenite. A-type rapakivi granites syenites crop out in the northern margin of Tarim (Carroll et al., 1995; Pirajno et al., 2008). In addition, Tarim was also the site of Mesozoic and Cenozoic non-marine sedimentation, with coal series deposited in Triassic to the Middle Jurassic (XBGMR, 1999).

Three Precambrian uplifts and one buried uplift, namely, Quruqtagh (also spelled as Kuruqtagh or Kuluktag) in NE, Altyn Tagh in SE and Tieklik in SW, and the central Tarim buried Precambrian uplift, occur in Tarim (Fig. 1). Paleoproterozoic and Neoarchean schist, gneiss and TTG (tonalite, trondhjemite and granodiorite) suite were scatteredly distributed both in the Altyn Tagh and Tieklik areas (Chen, 1998; Lu et al., 2008).

A 35 m thick diorite core, as evidence of Precambrian basement, was drilled out from the depth >7000 m beneath the central Tarim desert. Rare earth element patterns and isotopic compositions of Sr and Nd suggest that the central Tarim diorite was derived from an arc setting. The hornblende grains from the diorite yielded a little younger Ar–Ar plateau age of 790 ± 22 Ma (Guo et al., 2005) due to argon loss.

The sub-E–W-trending Quruqtagh uplift with a width of 50–70 km is located in the NE margin of Tarim. The voluminous Neoproterozoic slightly metamorphosed rocks (slate–phyllite, meta-igneous rocks) and various Mesoproterozoic, locally Paleoproterozoic–Archean schist, gneisses and amphibolites are exposed in Quruqtagh, which built up the ancient basement of Tarim (Gao et al., 1993; Guo and Zhang, 2003).

Four diamictite intervals related to Neoproterozoic glaciations (Xu et al., 2003, 2005a, 2008; Xiao et al., 2004) were well preserved. A Neoproterozoic continental rift environment was evidenced by various 830–740 Ma magmatic rocks in the northern Tarim Block, a response to the break-up of Rodinia (Chen et al., 2004; Huang et al., 2005; Zhang et al., 2006, 2007a).

The previous geochronological data from the TTG and other rocks from the Quruqtagh, Altyn Tagh and Tieklik areas suggest that the Tarim Block was mainly built up in several tectonic episodes at 2.65–2.45 Ga, 2.0–1.8 Ga and 1.1–0.9 Ga (Hu et al., 2000; Lu and Yuan, 2003; Zhu et al., 2008; Lu et al., 2008). Furthermore, Neoproterozoic bimodal and A-type igneous activities associated with rifting dated at 0.83–0.74 Ga have been documented in the Quruqtagh domain of Tarim (Zhang et al., 2006; Zhu et al., 2008; Deng et al., 2008).

Therefore the Quruqtagh domain is an important window for the understanding of the Precambrian tectonic framework and geodynamic evolution of Tarim and CAOB.

However, because few detailed field and petrographic characteristics were described the Precambrian stratigraphic sequence in Quruqtagh is little understood. Most of geochronological data published (XBGMR, 1993, 1999; Feng et al., 1995; Hu et al., 1999, 2000; Lu and Yuan, 2003) were analyzed using whole-rock

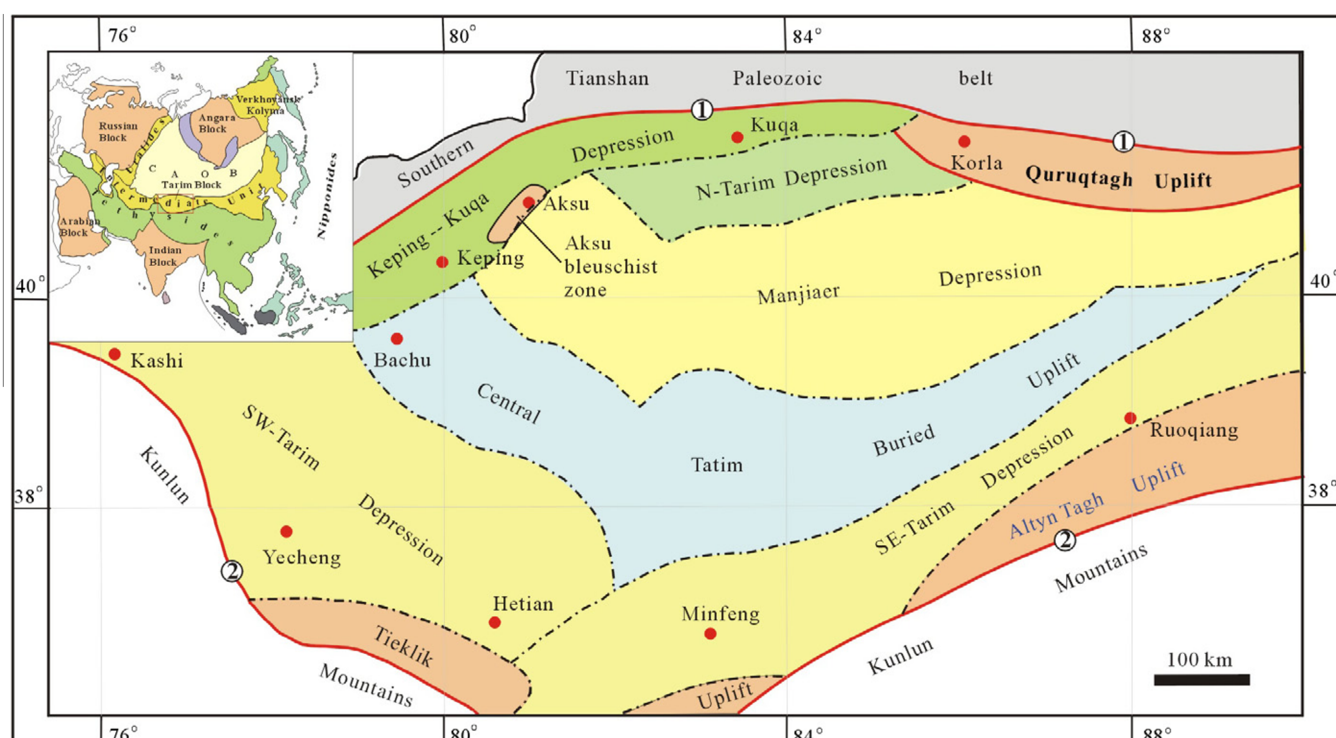

Fig. 1. Simplified tectonic framework of the Tarim Block: (1) the boundary fault between the Tianshan Orogenic Belt and the Tarim Block and (2) the boundary fault between the Kunlun orogeni belt and the Tarim Block.