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Tectonic framework and crustal evolution of the Precambrian basement of the Tarim Block in NW China: New geochronological evidence from deep drilling samples

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ABSTRACT

Based on new petrographic observations and zircon U–Pb geochronological data of the Precambrian basement from deep drilling cores in the Tarim basin and comparison with the Precambrian basements surrounding orogenic belts of the Tarim basin, we reconstruct a possible unified Tarim block. Data presented in this contribution lead to a three-fold subdivision of the pre-900 Ma basement of the Tarim block into the North Tarim terrane, the South Tarim terrane and the Central Tarim terrane. The North Tarim terrane containing Precambrian basements of the northern part of the Tarim basin, the Korla-Kuluketage and the Dunhuang area possesses a ca. 2.7–2.5 Ga or an even older continental nucleus and underwent multiple phases of magmatic and metamorphic events at ca. 2.0–1.8 Ga, 1.0–0.8 Ga and 760–687 Ma. The South Tarim terrane including Precambrian basements of the southern part of the Tarim basin, eastern Kunlun and western Kunlun orogenic belts, possesses a 2.4–2.3 Ga continental nucleus and underwent 2.0–1.75 Ga and 1.0–0.8 Ga metamorphic and magmatic events. The Central Tarim terrane encompassing Precambrian basement of the central part of the Tarim basin and the Altun orogenic belt, is characterized by magmatic arc system during 940–890 Ma. The unified Tarim Block was assembled as part of Rodinia supercontinent after series of geological processes, e.g. (1) breakup between the North and South Tarim terranes, (2) formation of the Central Tarim ocean, (3) subduction-related magmatic arc accretion, and (4) finally amalgamation of the North and South Tarim terranes during 1.0–0.8 Ga. There are two phases of the middle Neoproterozoic magmatic activities at 820–760 Ma and 760–687 Ma, respectively. They were most possibly related to the two phases of the Rodinia plume activities. The late Mesoproterozoic to Sinian assembly and breakup of the Rodinia led to the typical double-layered structure of the Tarim Block, i.e. the Pre-Nanhuaian basement and the Nanhuaian to Sinian cover sequence. Based on this study, we suggest that the unified Tarim Block, composed of Precambrian basement of Tarim basin and its surrounding orogenic belts, should be more large than the present Tarim basin.

1. Introduction

Situated in the northwestern China, the Tarim basin is bounded by the Tianshan Mountains to the north and northwest, and the West Kunlun-Altun Mountains to the south and southeast, respectively (Fig. 1).

The Tarim basin is recognized as a large-scale marine-continental sedimentary basin from Paleozoic to Cenozoic overlain on the Precambrian metamorphosed basement. Many geologists used the term "Craton" for an old and stable part of the continental crust such as the N-China, S-China and Tarim Cratons. Due to stable Early Paleozoic covers on the basement lied in the internal part of the Tarim basin (He and Li, 1996; Jia et al., 2004; Zhao and Cawood, 2012), and the unstable sedimentary covers located in surrounding orogenic belts of the Tarim basin (Xu et al., 2011). Therefore, we use the term "Tarim Block" in this text.

The Precambrian basement of the Tarim Block, mainly composed of Archean to early Neoproterozoic metamorphosed strata and magmatic rocks, is widely exposed in the surrounding orogenic belts of the Tarim basin (Fig. 1). According to previous studies focused on the Precambrian outcrop at Aksu, Korla, Kuluketage, Dunhuang, West Kunlun and Altun area (Chen et al., 2004; Xu et al., 2005, 2009; Zhan et al., 2007; Zhang et al., 2007a, 2009b, 2012a; Shu et al., 2011; Zhu et al., 2011; Yong et al., 2013), the

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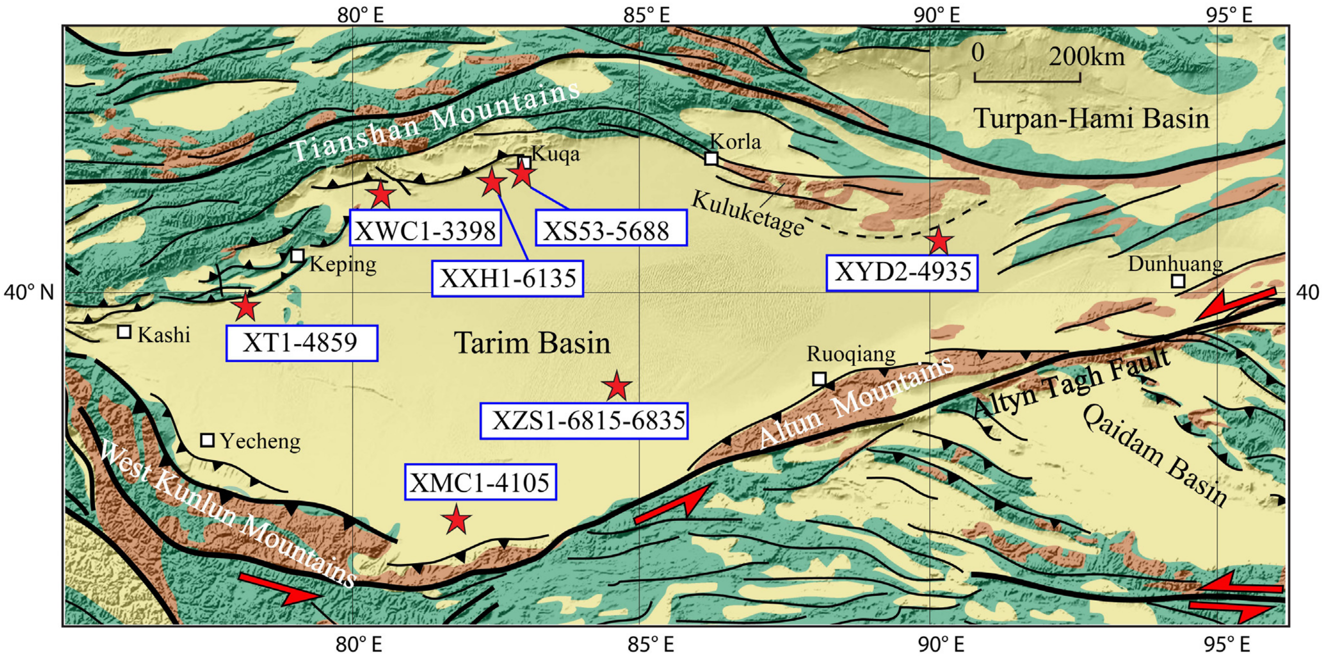

Fig. 1. A sketch structural map of the Tarim basin and its adjacent areas (modified after Xu et al., 2011), showing the locations of samples collected from drilling holes in this study. The solid coarse lines represent suture zones or boundary faults between Tarim and its neighboring orogenic belts.

Tarim Block is characterized by a double-layer structure consisting of Precambrian basement overlain by the Neoproterozoic to Cambrian sedimentary cover sequences. It experienced several stages of tectonic evolution since its formation, with both similarities and dissimilarities to the North and South China Blocks on many aspects. Furthermore, difficulties in obtaining the basement samples at deep depths beneath the Tarim basin have hindered further understanding its Precambrian tectonic processes of crustal growth and reworking. Moreover, there is still hot controversy on the comparisons of the basement of the Tarim basin with those distributed in its surrounding mountains, as well as with other main blocks of China (e.g. the North China and South China) (Hu et al., 2000, 2006; Shu et al., 2011; Zhu et al., 2011; Zhang et al., 2012b, 2013a,b; He et al., 2012). Some researchers suggest that the Tarim Block has unified Precambrian basement (e.g. Jia et al., 2004; Zhang et al., 2013a), but others argue that the basement of the Tarim block was collaged by two individual terranes at the north and south bounded by a central high magnetic anomaly zone in the central Tarim basin (Yin and Nie, 1996; Guo et al., 1999; Li et al., 2005; Guo et al., 2005). Therefore, directly deep drilling sampling of Precambrian rocks beneath the Tarim Basin can provide important constraints on these controversial issues.

In this study, we collect seven samples from seven deep drilling holes in the northern, central and southern parts of the Tarim basin. Petrographical and geochronological data of these valuable samples are applied to evaluate the earlier models and discuss the tectonic evolution of the Precambrian basement of the Tarim basin.

2. Regional geology

The Precambrian basement of the Tarim block mainly crop out in four areas surrounding the orogenic belts of the basin, i.e. the Korla-Kuluketage area, the Aksu-Keping area, the Tiekelike area and the Altun-Dunhuang areas at the NE, NW, SW and SE margins of the Tarim basin, respectively.

2.1. The Precambrian basement of the Korla-Kuluketage area

2.1.1. The Korla area on the northern margin of the Tarim basin

Recent studies have revealed that the Precambrian basement rocks at the Korla area at the northern margin of the Tarim basin are composed mainly of Archean arc-signature calc-alkali gneiss granites and Paleoproterozoic schist, gneiss, amphibolite, marble and minor TTG-like granitic intrusive rocks (Long et al., 2010, 2011a,b; Zhang et al., 2012a). The Paleoproterozoic amphibolite-facies metamorphic rocks have a mineral assemblage of plagioclase + K-feldspar + quartz + biotite ± muscovite ± hornblende ± garnet (Long et al., 2010). Zircon U–Pb dating demonstrates that these high-grade metamorphic rocks underwent three-stages of tectono-thermal events, i.e. the early Paleoproterozoic magmatic event at ca. 2370 Ma, the late Paleoproterozoic metamorphic event at 1890–1800 Ma and the early Neoproterozoic metamorphic event at 980–910 Ma (Dong et al., 2011; Zhang et al., 2012a). He et al. (2012) reported ca. 820–800 Ma granulites in this area and argued that these Neoproterozoic granulites were genetically related to the assembly of the Rodinia. In addition, minor 650–630 Ma mafic dykes and granites intruded into these metamorphic rocks (Zhu et al., 2008).

2.1.2. The Kuluketage area on the northeastern margin of the Tarim basin

The oldest rock exposed at the Kuluketage area is termed as the Kuluketage and Tuogelakebulake complexes, composed of TTG gneisses with amphibolites and calc-alkaline granites (Zhang et al., 2012a). Petrographically, the Neoarchean rocks could be divided into, the TTG (tonalite, trondhjemite, granodiorite as well as granites), calc-alkaline granites and high Ba–Sr granites. Zircon U–Pb dating indicates that the TTG rocks were mainly emplaced at ca. 2.7–2.6 Ga and then were intruded by the 2.53 Ga high Ba–Sr granites (Zhang et al., 2012a). In most places, the Archean rocks crop out as stripes or lens with variable dimensions and are tectonically enclosed within the Paleoproterozoic paragneiss. Both of the Archean igneous rocks and Paleoproterozoic paragneiss generally show concurrent foliations (Zhang et al., 2012a),