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Paleoproterozoic crustal evolution of the Tarim Craton: Constrained by zircon U–Pb and Hf isotopes of meta-igneous rocks from Korla and Dunhuang

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ABSTRACT

The Tarim Craton is one of three large cratons in China. Presently, there is only scant information concerning its crustal evolutionary history because most of the existing geochronological studies have lacked a combined isotopic analysis, especially an *in situ* Lu–Hf isotope analysis of zircon. In this study, Precambrian basement rocks from the Kuluketage and Dunhuang Blocks in the northeastern portion of the Tarim Craton have been analyzed for combined *in situ* laser ablation ICP-(MC)-MS zircon U–Pb and Lu–Hf isotopic analyses, as well as whole rock elements, to constrain their protoliths, forming ages and magma sources. Two magmatic events from the Kuluketage Block at ∼2.4 Ga and ∼1.85 Ga are revealed, and three stages of magmatic events are detected in the Dunhuang Block, i.e., ∼2.0 Ga, ∼1.85 Ga and ∼1.75 Ga. The ∼1.85 Ga magmatic rocks from both areas were derived from an isotopically similar crustal source under the same tectonic settings, suggesting that the Kuluketage and Dunhuang Blocks are part of the uniform Precambrian basement of the Tarim Craton. Zircon Hf model ages of the ∼2.4 Ga magmatism indicate that the crust of the Tarim Craton may have been formed as early as the Paleoarchean period. The ∼2.0 Ga mafic rock from the Dunhuang Block was formed in an active continental margin setting, representing an important crustal growth event of the Tarim Craton in the mid-Paleoproterozoic that coincides with the global episode of crust formation during the assembly of the Columbia supercontinent. The ∼1.85 Ga event in the Kuluketage and Dunhuang Blocks primarily involved the reworking of the old crust and most likely related to the collisional event associated with the assembly of the Columbia supercontinent, while the ∼1.75 Ga magmatism in the Dunhuang Block resulted from a mixture of the reworked Archean crust with juvenile magmas and was most likely related to a post-collisional episode.

1. Introduction

The Tarim Craton, located in northwestern China, is one of three major Precambrian cratonic blocks in China and covers an area of more than 600,000 km^2 (Fig. 1). This craton's central part is covered by Cenozoic desert, and Precambrian basement rocks are distributed primarily along the margins of the Tarim Craton, including Tieklik, Keping, Altyn Tagh–Dunhuang and Kuluketage (also spelled Quruqtagh or Kuruqtagh) in the southwest, northwest, southeast and northeast, respectively (Fig. 1; Dong et al., 2001; Lu et al., 2008; Turner, 2010; Zhang et al., 2013a). Moreover, as the southern border of the Central Asian Orogenic Belt, certain of the Precambrian microcontinents involved in the orogen were most likely torn from the Tarim Craton (Biske and Seltmann, 2010; Rojas-Agramonte et al., 2011; Ma et al., 2012a; Kröner et al., 2013).

As indicated by previous studies, these several exposed Precambrian basements of the Tarim Craton are apparently characterized by different forming ages and metamorphic conditions. The oldest rock in the Tieklik area is Akazi granodiorite with a formation age of ∼2.41 Ga and a metamorphic age of ∼1.9 Ga (Zhang et al., 2007a). The Neoproterozoic Aksu group in the Keping area experienced blueschist-facies metamorphism with disputed metamorphic ages, including ∼700 Ma (Nakajima et al., 1990; Zhu et al., 2011), ∼750 Ma (Liou et al., 1996; Yong et al., 2013), and 872–862 Ma (Chen et al., 2004). The Altyn Tagh–Dunhuang area has an Archean basement (Lu et al., 2008; Liu et al., 2009; Zhang et al., 2013b), which was strongly overprinted by the late Paleoproterozoic (Zhang et al., 2012a) and early Paleozoic orogeny (Meng et al., 2011; Zong et al., 2012). The basement rocks in the Kuluketage area are dominated by gray gneisses with lenses of supercrustal rocks and amphibolite (Guo et al., 2003; Hu and

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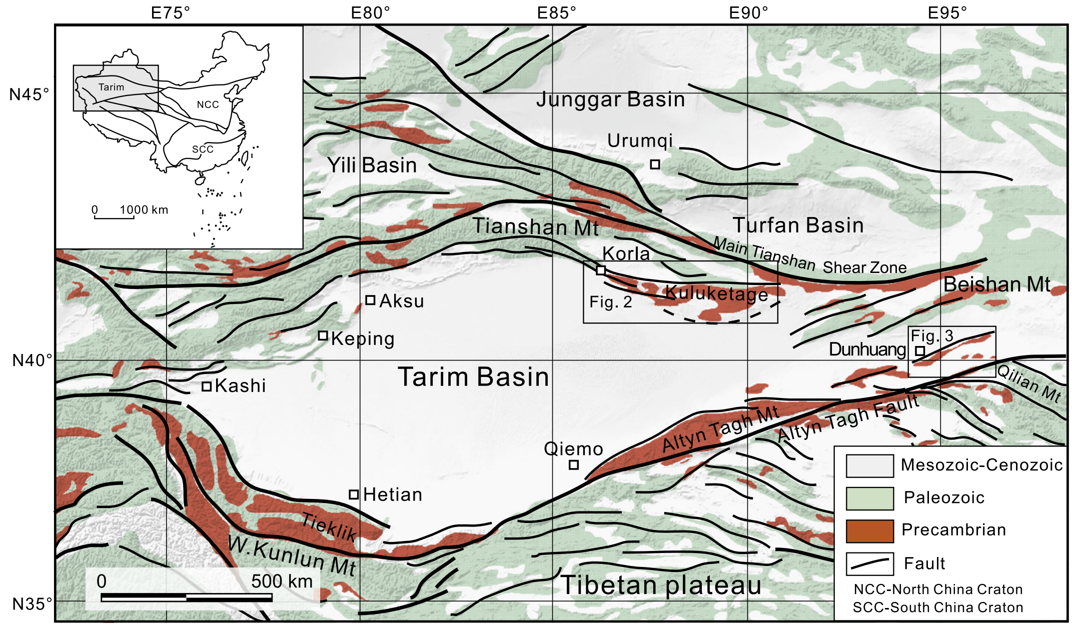

Fig. 1. Sketched tectonic and topographic map of the Tarim Craton depicting the distribution of the Precambrian basement outcrops (modified from Lu et al., 2008; Xu et al., 2011).

Wei, 2006). The gray gneisses were primarily formed during the late Neoarchean to the early Paleoproterozoic (2.65–2.46 Ga) and middle Paleoproterozoic (2.0–1.8 Ga) (Long et al., 2010, 2011a, 2012; Zhang et al., 2012b). In addition, a suite of Neoproterozoic granulite facies rocks were reported near the northern margin of the Kuluketage uplift (He et al., 2012).

However, it remains unclear whether the Tarim Craton has a uniform Precambrian basement or is composed of discrete crustal blocks. Furthermore, although there are abundant geochronological data as mentioned above, little is known regarding the source of the magmatic rocks, such as the juvenile depleted mantle, the reworked older crust or a combination of the two. Based on the magmatic and metamorphic evidence, it is well-accepted that the Tarim Craton was a part of the Columbia supercontinent (e.g., Shu et al., 2011; Zhang et al., 2013a,b; Ma et al., 2013). Addressing the above questions is also fundamental to understanding the tectonic evolution of this craton and its affinity with other crustal blocks within the supercontinent (e.g., Gong et al., 2012; Kaur et al., 2013; Zhang et al., 2013a,b). In this study, we conducted detailed zircon U–Pb and combined Hf isotopic studies on several Paleoproterozoic granitic gneisses and amphibolites from the Kuluketage and Dunhuang Blocks to determine their crystallization ages and magma sources and to obtain more insight into the Precambrian tectonic and crustal evolution of the Tarim Craton within the Columbia supercontinent. This craton is geologically an ideal test ground because of the relatively wider rock exposure area among the scattered and limited basement outcrops of the Tarim Craton and the well-known Archean rocks.

2. Geological background and sample collection

2.1. Kuluketage Block

The Kuluketage Block is located in the northeastern margin of the Tarim Craton, where excellent outcrops extend over an approximately 500-km length and 100–250 km in width that is structurally bounded by the Korla–Xinger fault and the Xingdi fault against the southern Tianshan Mountain and Tarim Basin, respectively (Shu et al., 2011). The Archean rocks are exposed primarily near the Xinger and Korla areas (Fig. 2), including the granitic gneisses of the Tuoge Complex, with ages of ~2.52–2.60 Ga (Hu and Wei, 2006; Long et al., 2010; Zhang et al., 2012b) and the granitic gneisses near Korla with an age of ~2.65 Ga (Long et al., 2011a; Zhang et al., 2012b). In addition, several granitoid bodies were also emplaced during the Paleoproterozoic to Neoproterozoic (Fig. 2; Luo et al., 2007; Long et al., 2010, 2011b; Shu et al., 2011; Zhang et al., 2012b). Paleoproterozoic to Neoproterozoic sedimentary rocks with varying metamorphic grades are scattered in the Kuluketage Block. Two unconformities occur at the base of the Mesoproterozoic strata and between the Neoproterozoic Kuluketage Group and the overlying Paergangtage Group, respectively (Lu et al., 2008). The Neoproterozoic Kuluketage Group is more than 6000 m thick, and it is characterized by several horizons of glacier deposits and volcanic rocks that are separated by thick layers of shale, sandstone and limestone (Xu et al., 2005, 2009). The crystallization ages of the volcanic rocks are between 740 Ma and 615 Ma (Xu et al., 2005, 2009). Otherwise, voluminous Neoproterozoic mafic dyke swarms occur in the southern part of the Kuluketage and near the Korla region that have been correlated with Neoproterozoic rifting events (Zhang et al., 2007b, 2009a,b, 2011, 2012c; Zhu et al., 2008, 2011).

Outcrops in the Korla area are primarily composed of gneisses and amphibolites of the Paleoproterozoic Xingditage Group, which is intruded by Neoproterozoic and Paleozoic granitoids (Fig. 2b; Long et al., 2011b; Zhang et al., 2012c). Two migmatitic gneiss samples were collected from a road cut between Korla and Tashidian (Fig. 2b). These gneisses exhibit a banded structure and intense deformation. The mineral assemblages and GPS positions are listed in Table 1.

2.2. Dunhuang Block

The Altyn Tagh–Dunhuang uplift in the southeastern margin of the Tarim Craton is traditionally called Dunhuang Block (Fig. 1; Lu and Yuan, 2003), which is a triangular block bounded by the Beishan Mountain, the Altyn Tagh Mountain and the Altyn Tagh Fault. The Dunhuang Block is a high-grade metamorphic province,