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Is the Precambrian basement of the Tarim Craton in NW China composed of discrete terranes?

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ABSTRACT

The Precambrian evolution of the Tarim Craton in NE China, in particular during the early Precambrian stage, remains enigmatic. In this contribution, we report field observation, petrology, geochemistry, zircon Lu–Hf isotopes and U–Pb ages of the major rock formations of the Aketage area in the southeastern section of the Tarim Craton. The Milan Group in Aketage is dominantly composed of 2.7–2.5 Ga gneissic amphibolite–TTG complex with minor paragneiss. Both the mafic and silicic rocks exhibit geochemical features consistent with an arc affinity. The arc-signature of the 2.01–2.03 Ga gneissic granites and gabbros which intrude the Archean basement, as well as the major 2.0 Ga metamorphic event revealed by zircon U–Pb dating, suggest an important subduction-collision event possibly related to the assembly of the Paleoproterozoic Columbia supercontinent. The ca. 1848–1856 Ma massive potassic granites, 1867 Ma mafic dyke swarm and 1844 Ma massive leucogranite dykes reveal magmatism in a post-collisional extensional setting.

A comprehensive synthesis of the major orogenic events and continental crust growth process from the different Precambrian terranes in Tarim Craton show significant discrepancy in time related to the late Neoarchean crust formation ages and the Paleoproterozoic orogenic events. For example, the major orogenic event took place at ~1.85 Ga in Quruqtagh-Dunhuang terrane, at ~1.90 Ga in the southwest Tarim Craton and at ~2.0 Ga in the Aketage-Qaidam terrane. These different terranes exhibit distinct periods of continental crust growth in the early Precambrian. Continental growth in the Aketage area took place during 2.7–4.3 Ga. The 3.6 Ga xenocrystic zircons as well as the peak of 4.2 Ga zircon Hf model ages, indicate the possible existence of Paleoarchean and even Hadean crust in the Aketage area. In the Quruqtagh-Dunhuang terrane, the growth of early Precambrian continental crust took place at 2.6–3.3 Ga with peaks at ca. 2.6–2.7 Ga and 3.0 Ga. The diachronous late Paleoproterozoic orogenic events and the significant difference in continental growth process suggest that the Precambrian basement of the Tarim Craton is composed by independent continental terranes possibly detached from the cores of discrete ancient cratonic nuclei, which were not unified until the early Neoproterozoic during assembly of the Rodinia supercontinent.

1. Introduction

The Tarim Craton, located within the Xinjiang Uygur Autonomous Region of northwestern China and covering an area of more than 600,000 km^2, is one of the main three Precambrian nuclei in China (i.e., Tarim, North China and South China) (Zheng et al., 2013). The Tarim Craton is surrounded by the orogenic belts of Tienshan Mountains to the north, the western Kunlun Mountains to the south, and the Central-Southern Altyn Tagh Mountains to the southeast (Fig. 1a). Since most part of the Tarim Craton is covered by aeolian sands and also because of the difficulties in accessibility, the Precambrian basement of Tarim Craton remains obscure.

In recent years, many studies focusing on the Neoproterozoic geology of Tarim Craton revealed that the craton was assembled within the Rodinia supercontinent during 1.0–0.9 Ga, and even lasted to 780 Ma (Zhang et al., 2003, 2012a, 2014; Shu et al., 2011; He et al., 2013; Yong et al., 2013). The two main pulses of Neoproterozoic magmatism at 820–800 Ma and 780–760 Ma have been correlated to the Rodinian plume activity (Zhang et al., 2007a, 2009,

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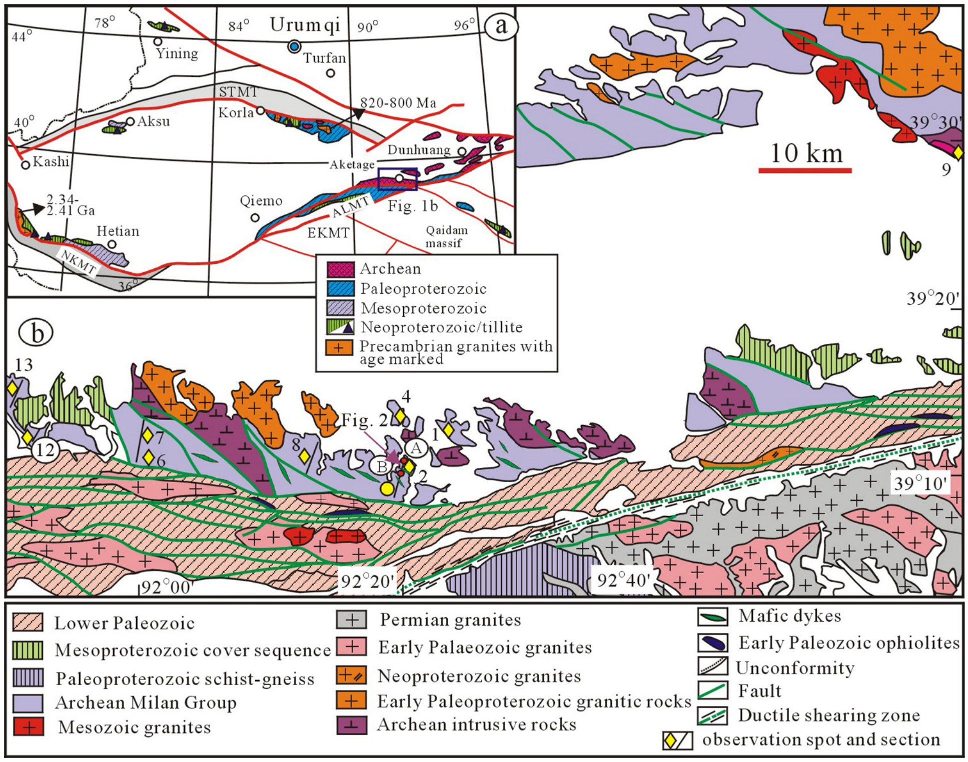

Fig. 1. (a) Tectonic framework of the Tarim Craton and its marginal area showing the Precambrian terranes along its margin. (b) Precambrian geology in Aketage area in the eastern section of the Tarim Craton. The field observation spots and sections are shown and the number beside the diamond symbol shows our sampling locality and correspond with the sample numbers in the text and Supplementary Table S1.

2012a; Xu et al., 2005, 2009). The limited geochronological data for the early Precambrian history of this craton shows 2.0–1.80 Ga metamorphism along the northern margin (the Quruqtagh uplift), the Tiekelike uplift in southwest and the Altyn in the east, all of which have been correlated to the assembly of the Columbia supercontinent (Lu et al., 2008; Shu et al., 2011; Long et al., 2010, 2011a,b; Zhang et al., 2011; He et al., 2013). However, a number of questions remain to be addressed such as: (1) When did the Tarim Craton acquire a unified Precambrian basement? (2) Did the different Precambrian terranes around the Tarim Craton (Fig. 1a) experience similar Precambrian tectonic evolution? (3) Do these Precambrian terranes share a common continental crust growth process?

With a view to obtain a better understanding of the early Precambrian evolution and continental crust growth in the Tarim Craton, we report new geological, geochronological and geochemical data from the early Precambrian rocks in Aketage area along the southeastern margin of the craton. Based on the results from this study and previous data, we investigate the processes and timing of cratonization in Tarim and their correlation with the assembly and breakup of early Precambrian supercontinents.

2. Regional geology and field observations

The early Precambrian rocks in Tarim Craton are mostly exposed along the eastern and northern margins of the craton (Fig. 1a). These major rock types include Neoarchean tonalitic–granitic units, and the Paleoproterozoic amphibolite to granulite facies paragneiss (Lu, 1992; Lu et al., 2002; Lu and Yuan, 2003; Zhang et al., 2013a). The Neoarchean gneissic granitoids in Quruqtagh can be divided into three groups: the TTG (tonalite, trondhjemite, granodiorite as well as gabbro enclaves), calc-alkaline granites and high Ba–Sr granites. Recent high-precision zircon U–Pb ages indicate that the TTG rocks were mainly emplaced at ca. 2.7–2.6 Ga and that these were intruded by the 2.53 Ga high Ba–Sr granites (Zhang et al., 2012b).

Similar to the scenario in the Quruqtagh, previous studies have classified the early Precambrian lithounits in Altyn-Tagh and Dunhuang area as Archean Milan Group and Paleoproterozoic Altyn Mountain Group based on limited imprecise isotope ages (e.g., Xinjiang BGMR, 1993; Lu et al., 2002). In recent years, geological mapping, geochronological and geochemical studies revealed that the Milan Group is composed of Archean TTG rocks (2.7–2.6 Ga) (Lu et al., 2008; Liu et al., 2010), hypersthene granulite, and mafic granulite (Lu et al., 2008). The supracrustal sequences are represented by aluminous metapelites and minor graphite-bearing marble, similar to the 'khondalite series' in the North China Craton. They are also comparable with the paragneiss from Quruqtagh in their similar petrographic features (Lu et al., 2002, 2008).

This study focuses on the Early Precambrian units in Aketage area immediately to the north of Altyn-Tagh (Fig. 1b), where the oldest xenocrystal zircons in Tarim were reported (~3.6 Ga, Lu et al., 2008). Our field observations show that the Milan Group in this area is mainly composed of silicic orthogneiss with minor amphibolites (grey gneiss) and paragneiss (Figs. 2 and 3a–c). These gneisses are intruded by diverse magmatic rocks including gneissic granites, massive granites and mafic dykes (Figs. 2 and 3d–h). In several places, the massive granites, mafic dykes and some leucogranite dykes intrude into the gneissic granites and the gneisses of Milan Group (Fig. 3b and e–h). Generally, amphibolite enclaves occur within the felsic gneiss and both of these share concurrent gneissic structure (Fig. 3c), indicating that they underwent a similar deformation history before the intrusion of the mafic dykes and massive granites. Based on field observations, we divide the igneous activities in the Aketage area into an early stage of the gneissic granites and gabbros, and a late stage of the massive granites and mafic dykes (Fig. 2).