Precambrian Research 254 (2014) 194–209

Contents lists available at ScienceDirect

Precambrian Research

journal homepage: www.elsevier.com/locate/precamres

Detrital zircon U–Pb ages and Hf isotopes of Neoproterozoic strata in the Aksu area, northwestern Tarim Craton: Implications for supercontinent reconstruction and crustal evolution

Jingwen He, Wenbin Zhu*, Rongfeng Ge, Bihai Zheng, Hailin Wu

State Key Laboratory for Mineral Deposits Research, School of Earth Sciences and Engineering, Nanjing University, Nanjing 210093, PR China

ARTICLE INFO

Article history:
Received 28 May 2014
Received in revised form 23 August 2014
Accepted 26 August 2014
Available online 2 September 2014

Keywords:
Detrital zircon geochronology
Hf isotopes
Crustal evolution
Rodinia
Gondwana
Tarim Craton

ABSTRACT

The northern margin of the Tarim Craton plays a pivotal role in understanding the crustal evolution and supercontinent reconstruction of the Tarim Craton. Here we integrate LA-ICP-MS U–Pb ages and Hf isotopic data for detrital zircons from Neoproterozoic successions in the Aksu area, NW Tarim. A total of 679 concordant U–Pb ages define four age populations of 2600–2200 Ma, 2050–1800 Ma, 950–700 Ma and 680–600 Ma, which are consistent with the episodes of magmatism and metamorphism documented in the northern Tarim Craton, suggesting that the detritus were likely sourced from the northern Tarim Craton itself. The oldest age population corresponds to the Neoarchean to early Paleoproterozoic magmatic event related to an important stage in the development of the proto continental crust in the Tarim Craton. The 2050–1800 Ma age population represents a magmatic–metamorphic event during a middle Paleoproterozoic orogeny, possibly related to the assembly of Tarim to the Columbia supercontinent. The dominant Neoproterozoic detrital zircons display a major cluster between 950 Ma and 700 Ma (peak at ca. 850 Ma), much younger than the typical Grenvillian ages. This is similar to detrital zircon data sets from Yangzte and northern India, implying that these blocks shared a similar evolution pattern in the Rodinia supercontinent. The early Pan-African (680–600 Ma) ages are comparable with those reported from the Arabian-Nubian Shield, but quite different from those from other Gondwana blocks, implying a possible correlation of Tarim with the Eastern Africa Orogen. Abundant zircons yield Archean (3.9–2.5 Ga) Hf model ages (T_{DM}^{C}), suggesting the presence of extensive Archean basement as old as Paleoarchean in the Tarim Craton. Some Neoarchean and Neoproterozoic zircons have high positive $\varepsilon_{Hf}(t)$ values, indicating significant juvenile addition from the depleted mantle at those periods. However, most detrital zircons show negative $\varepsilon_{Hf}(t)$ values, suggesting that crustal reworking was the dominant process in the generation of the episodes of magmatism in the Tarim Craton. At last, based on the stratigraphic settings and the comparison of detrital zircon data, the Aksu Group and the Qiaoenbrak Formation are most likely units with equivalent depositional age.

1. Introduction

As an ancient continental block in eastern Asia, the Tarim Craton is considered to be an important constituent of supercontinents such as Rodinia and Gondwana (e.g. Hoffman, 1991; Li et al., 1996, 2008; Evans, 2009; Wen et al., 2013). In the last decade, the role of the Tarim Craton in the Rodinia supercontinent was discussed in several investigations (e.g. Long et al., 2011; Zhu et al., 2011a; Ge et al., 2012; He et al., 2012, 2014a; Zhao and Cawood, 2012; Zhang et al., 2013a). Li et al. (1996, 2008) proposed a long-lived Tarim–NW Australia connection in Rodinia based on tectonostratigraphic correlation. The Tarim–Australia connection was generally supported by several paleomagnetic studies, although the detailed paleogeographic reconstruction is still controversial (Chen et al., 2004; Huang et al., 2005; Zhan et al., 2007; Wen et al., 2013; Zhao et al., 2014). Early Neoproterozoic (1.0–0.9 Ga) magmatism or metamorphism was reported in West Kunlun (Zhang et al., 2003) and Altyn Tagh–Qilian–North Qaidam areas (Song et al., 2012; Wang et al., 2013a; Tung et al., 2013; Yu et al., 2013). These litho-units were interpreted to have been formed in a Grenville orogen along the south margin of the Tarim Craton, providing a suitable candidate for the assembly of Tarim to the Rodinia supercontinent. In contrast, the north margin of the Tarim Craton may have a different

* Corresponding author. Tel.: +86 25 83592921; fax: +86 25 83686016.
E-mail address: zwb@nju.edu.cn (W. Zhu).

http://dx.doi.org/10.1016/j.precamres.2014.08.016
0301-9268/

Neoproterozoic tectonic history. Most magmatic rocks in the northern Tarim Craton were dated between 830 Ma and 615 Ma, and were commonly interpreted as a result of multiple episodes of mantle plume activity related to the breakup of the Rodinia supercontinent (Xu et al., 2005, 2009, 2013; Zhang et al., 2006, 2007, 2009a, 2010, 2011, 2012a; Zhu et al., 2008, 2011b; Long et al., 2011; Shu et al., 2011). However, this interpretation is challenged by several recent studies. For example, He et al. (2012) recently discovered 830–790 Ma high-grade metamorphic rocks, and Zhang et al. (2013b) argued that the Bayisi volcanic rocks (743–725 Ma) were formed in a continental arc setting, rather than a rift. Ge et al. (2013a, 2014) proposed a regional orogenic event at 830 Ma in the northern Tarim Craton.

In contrast, less attention has been paid to the link between Tarim and the Gondwana supercontinent. Recently, Ge et al. (2012) reported 660–630 Ma potassic granitoids in the Korla area and proposed an early Pan-African accretionary orogeny in the northern Tarim Craton. Ma et al. (2012) found a detrital zircon age peak at ca. 560 Ma from Central Tianshan, a continental fragment possibly rifted off the northern Tarim Craton (He et al., 2014b). These geochronological records are coeval with the widespread Pan-African tectonothermal event from many Gondwana blocks. Furthermore, comparison of apparent pole wander paths (APWPs) of Tarim and Australia suggests a long-term Australia–Tarim connection until the Middle Silurian (Zhao et al., 2014). These results indicate that the Tarim Craton may have a close affinity with the Gondwana supercontinent. However, the palaeogeographic position of the Tarim Craton and its link with other major blocks in the Gondwana supercontinent is still uncertain.

Precambrian successions exposed in the Aksu area provide us a window to investigate the tectonic evolution history of the Tarim Craton during the amalgamation and dispersal of the ancient supercontinents. The blueschists in the Aksu Group is regarded as one of the oldest well-substantiated blueschists in the world (Liou et al., 1989; Nakajima et al., 1990; Zheng et al., 2010; Zhu et al., 2011a; Yong et al., 2013), indicating a pre-Sinian high-pressure/low-temperature (HP-LT) metamorphism due to oceanic subduction (Liou et al., 1989; Nakajima et al., 1990; Zhu et al., 2011a). In addition, Neoproterozoic diamictites, mafic dykes and lavas are also well-exposed and of wide interests due to their significance in understanding the Snowball Earth hypothesis and supercontinent breakup (Gao et al., 1993, 2013; Zhang et al., 2009a; Zhu and Wang, 2011). However, many controversies exist about the age and significance of these rocks due to lack of precise isotopic age constraints. Recently, Zhu et al. (2011a) obtained maximum depositional ages of 730 Ma and 602 Ma for the Aksu Group and the Sugetbrak Formation. However, detrital zircon age data are still lacking for other stratigraphic units (e.g. the Qiaoenbrak and Yuermeinak formations), and no Hf isotopic data are available in the Aksu area, preventing a deep understanding of their regional correlation, sedimentary provenance and broader geological significance.

Integrated detrital zircon U–Pb and Lu–Hf characteristics has been proved as a useful tool to constrain the depositional ages of clastic sedimentary rocks and to reveal the crustal evolution and continental affinity in the supercontinent (e.g. Yu et al., 2008; Yao et al., 2011; Ma et al., 2012; Zhu et al., 2011a; Wang et al., 2012; He et al., 2014a). Here we present LA-ICP-MS detrital zircon U–Pb ages and in situ Lu–Hf isotopic data for Neoproterozoic successions in the Aksu area. Our data reveal episodic tectonic events in the Tarim Craton, which are well correlated with supercontinent circles. We also compare our detrital zircon data with those from some other continental blocks to evaluate the position of Tarim in the Rodinia and Gondwana supercontinents.

2. Geological setting

As a major tectonic unit in Xinjiang Province, northwestern China, the Tarim Craton is surrounded by the Tianshan Mountains to the north and the Tibet Plateau to the south. Precambrian outcrops are mainly exposed in Kuruktag, Aksu, West Kunlun and Altyn Tagh–Dunhuang belt on the margin of the Tarim Basin (Fig. 1A; Lu et al., 2008). In the Aksu area, NW Tarim, Neoproterozoic rocks are well-exposed at the south Aksu, Wushi and Yuermeinak–Sugetbrak areas (Fig. 1B; Turner, 2010; Xu et al., 2013). However, there are still considerable disagreements about the regional correlation and geological significance of these rocks mainly due to lack of reliable geochronological constraints.

In the south Aksu and Wushi areas, the Sinian (Edicaran) Sugetbrak and Qigebrak formations unconformably overlie the blueschist-bearing Aksu Group (Fig. 2A). The Aksu group comprises pelitic, psammitic and mafic schists, the latter including the greenschists and blueschists. The schists were strongly deformed (Fig. 3A), and four phases of folding were described by Zhu et al. (2011a). In addition, a series of NW-trending unmetamorphosed mafic dykes intruded the Aksu Group and were unconformably overlain, along with the Aksu Group, by the Sugetbrak Formation (Zhang et al., 2009a; Zhu et al., 2011a). Such a field relationship indicates the following sequence of events: (1) formation and blueschist facies metamorphism; (2) early exhumation of the metamorphic schists; (3) mafic dyke intrusion; (4) late exhumation and erosion of the blueschists and mafic dikes; and (5) deposition of the Sugetbrak and Qigebrak formations.

However, the precise metamorphic age of the Aksu Group and intrusion age of the mafic dikes is debated. Some researchers suggested a Grenvillian oceanic subduction and HP-LT metamorphism, possibly related to the amalgamation of Rodinia around 1.0 Ga. This is mainly based on whole-rock Rb–Sr ages of the blueschists (962 ± 12 and 944 ± 12 Ma; Gao et al., 1993) and zircon U–Pb ages of the intruding mafic dykes (807 ± 12 Ma, 785 ± 31 Ma and 759 ± 7 Ma; Chen et al., 2004; Zhan et al., 2007; Zhang et al., 2009a). In contrast, other researchers favored a late Neoproterozoic metamorphic age (750–700 Ma) based on several whole-rock or mineral K–Ar, $^{39}Ar/^{40}Ar$, Rb–Sr ages (Nakajima et al., 1990; Liou et al., 1996; Yong et al., 2013) and the maximum depositional age from detrital zircons of the psammitic schists (~730 Ma; Zhu et al., 2011a). The latter authors interpreted that the Aksu blueschists may be associated with a Pan-African orogeny during the assemblage of the Gondwana supercontinent and argued that the variable zircon ages of the intruding mafic dykes are xenocryst ages.

The overlying Sugetbrak Formation is in sharp and angular unconformity contact with the Aksu Group in the south Aksu and Wushi areas. The base of the Sugetbrak Formation is characterized by a red conglomerate succession in direct contact with the schists of the Aksu Group (Fig. 3B). Pebbles of quartzites, mafic dikes, pelitic schists, psammitic schists and blueschists are found in the Sugetbrak conglomerate (Fig. 3C and D). The remaining part of the Sugetbrak Formation comprises, in an ascending order, red fluvial sandstones interlayered with several horizons of basalt in the middle (Fig. 3E) and gray-green thin-layered sandstones and mudstones in the top (Fig. 3F). Two to four horizons of basalts with thickness ranging from 5 to 30 m are observed at different locations. The conformably overlaying Qigebrak Formation is characterized by interlayered gray stromatolitic and dolomitic limestones.

In the Yuermeinak-Sugetbrak area, the Neoproterozoic successions are different with those in the south Aksu and Wushi areas. Here the Qiaoenbrak Formation is unconformably overlain by the Yuermeinak, Sugetbrak and Qigebrak formations. The blueschists-bearing Aksu Group is absent. Two layers of diamictite are well preserved in the Qiaoenbrak and Yuermeinak formations, respectively (Fig. 2B). The Qiaoenbrak Formation is subdivided into, from