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Generation of ca. 900–870 Ma bimodal rifting volcanism along the southwestern margin of the Tarim Craton and its implications for the Tarim–North China connection in the early Neoproterozoic

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ABSTRACT

Large scale rift related volcanic suites are widely accepted as the evidence of the initial breakup of supercontinents and thus can be used to reconstruct the relative position of the cratons. Numerous early Neoproterozoic volcanic rocks have been identified in the Tiekelik Belt, southwestern part of the Tarim Craton. The Sailajiazitage volcanic rocks in the Tiekelik Belt are composed of a suite of bimodal volcanics and related pyroclastic rocks. The geochemical characteristics resemble those of continental flood basalts (CFBs) formed in the shallower mantle dominated by spinel–lherzolite with EM2 affinities. The rhyolites have been dated at 896 ± 11 Ma at the base, 881 ± 14 Ma at the middle and 872 ± 8 Ma at the top by U–Pb method on zircon. They erupted in an intraplate rift environment and are interpreted to have formed by crustal melting. Hf isotopes of individual dated zircon grains show a wide range of initial ε_{Hf} values, from strongly negative (down to −28) to highly positive (up to +12.8), indicating a mixture of mantle- and crustal-derived materials. The bimodal volcanic suite is overlain by the Bochatetage Formation sediments, deposited sometime after 797 ± 12 Ma. An identical ca. 900–870 Ma age for rift-related volcanic rocks indicate Neoproterozoic regional extensional processes in the southern margin of the Tarim–North China, which allow us to speculate on the correlation of the Tarim and North China cratons during the Neoproterozoic. This voluminous bimodal magmatism resembles the rift-related magmatism in the North China, West African, Congo and São Francisco cratons of age ca. 925–870 Ma, suggesting that the Tarim Craton was located close to these cratons during early Neoproterozoic, or alternatively, that such early Neoproterozoic rift magmatism was widespread over large parts of Rodinia.

1. Introduction

Reconstruction of the Rodinia supercontinent is a long-standing and difficult problem (e.g., Moores, 1991; Dalziel, 1991; Hoffman, 1991; Wingate et al., 2002; Li et al., 2008; Evans, 2009; Johansson, 2014). Breakup of the supercontinents has been thought to be the product of mantle plumes and/or super mantle plumes (e.g., Coffin and Eldholm, 1992; Condie, 2001; Maruyama et al., 2007; Santosh et al., 2009; Ernst et al., 2005; Campbell, 2006; Phillips and Bunge, 2007; Li et al., 2008; Li and Zhong, 2009; O'Neill et al., 2009; Coltice et al., 2009; Yoshida and Santosh, 2011; Johansson, 2014). Mantle plumes can induce large scale but short-lived magmatism, such as thick flood basalts, huge mafic dyke swarms, and rift-related bimodal volcanic suites. Thus such magmatism has been considered as vital evidence of initial breakup of supercontinents and has been widely used to correlate and reconstruct the supercontinents (e.g., Storey, 1995; Courtillot et al., 1999; Ernst et al., 2005, 2008, 2013; Ernst, 2014; Bleeker, 2003; Li et al., 2008; Santosh et al., 2009). By ca. 900 Ma all major continental blocks are believed to have amalgamated along the Grenville Orogeny (ca. 1300–900 Ma) and similarly aged orogenic belts around the world to form the Rodinia supercontinent (Hoffman, 1991; Li et al., 2008). However, there were still some penecontemporaneous or slightly younger intraplate magmatism, which could be related to the initial break-up of the supercontinent Rodinia (e.g., Peng et al., 2011a,b; Kouyate et al., 2013). These assembly and break-up events provide a vital clue when reconstructing the paleogeographic and tectonic history of the Earth in early Neoproterozoic times.

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There are three cratons in China: Tarim (TC), North China (NCC) and South China (SC) (Fig. 1a). In the most popular reconstruction model of Rodinia (Li et al., 2008), these three cratons were isolated from each other. However, there is debate on this point given the similarity of the basement of the TC, NCC and SC. Based on the correlation of the Neoproterozoic magmatism and stratigraphic sequences, it has been proposed that the SC and TC were connected but the NCC was isolated due to the absence of the Neoproterozoic magmatism in the NCC as previously believed (Lu et al., 2003, 2008). Recent studies TC have revealed much resemblance with the NCC in terms of Paleoproterozoic magmatic and metamorphic histories, which leads to the correlation between the TC and NCC (Ge et al., 2013; Wang et al., 2014). In addition, newly identified Neoproterozoic mafic dykes and rifting volcanics in the NCC increased evidence for correlations between the NCC and the other blocks (Liu et al., 2006; Wang et al., 2011, 2012; Peng et al., 2011a,b).

Due to the extensive younger cover of the Taklamakan desert in the central part of the craton, the basement of the Tarim Craton of northwest China is only exposed along the margins of the main basin (Fig. 1b). These exposures include two regions along the southern margin of Tarim (Tiekelik and North Altyn–Dunhuang) and the Aksu and Kuluketage areas at the northern margin. Previously published data indicate that two major Paleoproterozoic 'events' took place: at 2.45–2.25 Ga (magmatism) and 2.0–1.8 Ga (magmatism and metamorphism; Wang et al., 2014 and references therein). Recent research on the Tarim Craton (Fig. 1a) has demonstrated clear signatures of Neoproterozoic orogenic and break-up processes which have been interpreted as a local expression of the assembly and breakup of the Rodinia supercontinent (Xu et al., 2005; Guo et al., 2005; Zhang et al., 2007, 2009, 2010a, 2012; Shu et al., 2011; Lu et al., 2008; Turner, 2010; Long et al., 2011) or the early Pan-African accretionary orogeny (Ge et al., 2012). However, these studies mainly focused on the northern margin of the Tarim Craton. The Neoproterozoic evolution of the southern margin of the Tarim Craton is still poorly studied (e.g., Zhang et al., 2004; Wang et al., 2009, 2013), which hinders evaluation of the relationships of the Tarim Craton with other cratons. A narrow, but important, NW–SE to E–W-trending region known as the Tiekelik Belt (Figs. 1b and 2) lies along the southwestern margin of the Tarim Craton. Recent geochronological studies identified Neoproterozoic magmatic activity in the Tiekelik Belt (Zhang et al., 2004, 2010a; Wang et al., 2009, 2015). However, the Sailajiazitage bimodal volcanic rocks that are widely distributed in the central parts of the Tiekelik Belt lack detailed geochronological and geochemical data. In this contribution, we present geochemical and zircon U–Pb–Hf isotopic data for the Sailajiazitage volcanic rocks of the Tiekelik Belt with a view to determining their age and petrogenesis. This study provides a reappraisal of the age of some lithological units of the Tiekelik Belt, and a refinement of the magmatic barcode for the Tarim Craton. Finally, comparison of this early Neoproterozoic rift magmatism with that of the NCC in a global context is used to discuss the possible position of the Tarim Craton in Precambrian supercontinents.

2. Geological background

Rocks exposed in the Tiekelik Belt mainly consist of Palaeoproterozoic amphibolite-facies migmatites, gneisses and granitoids and Neoproterozoic (meta-) sedimentary and metavolcanic rocks, which are overlain by late Paleozoic to Cenozoic terrigenous sedimentary rocks (Fig. 2) (e.g., RGXR, 1993). Strata within the Tiekelik

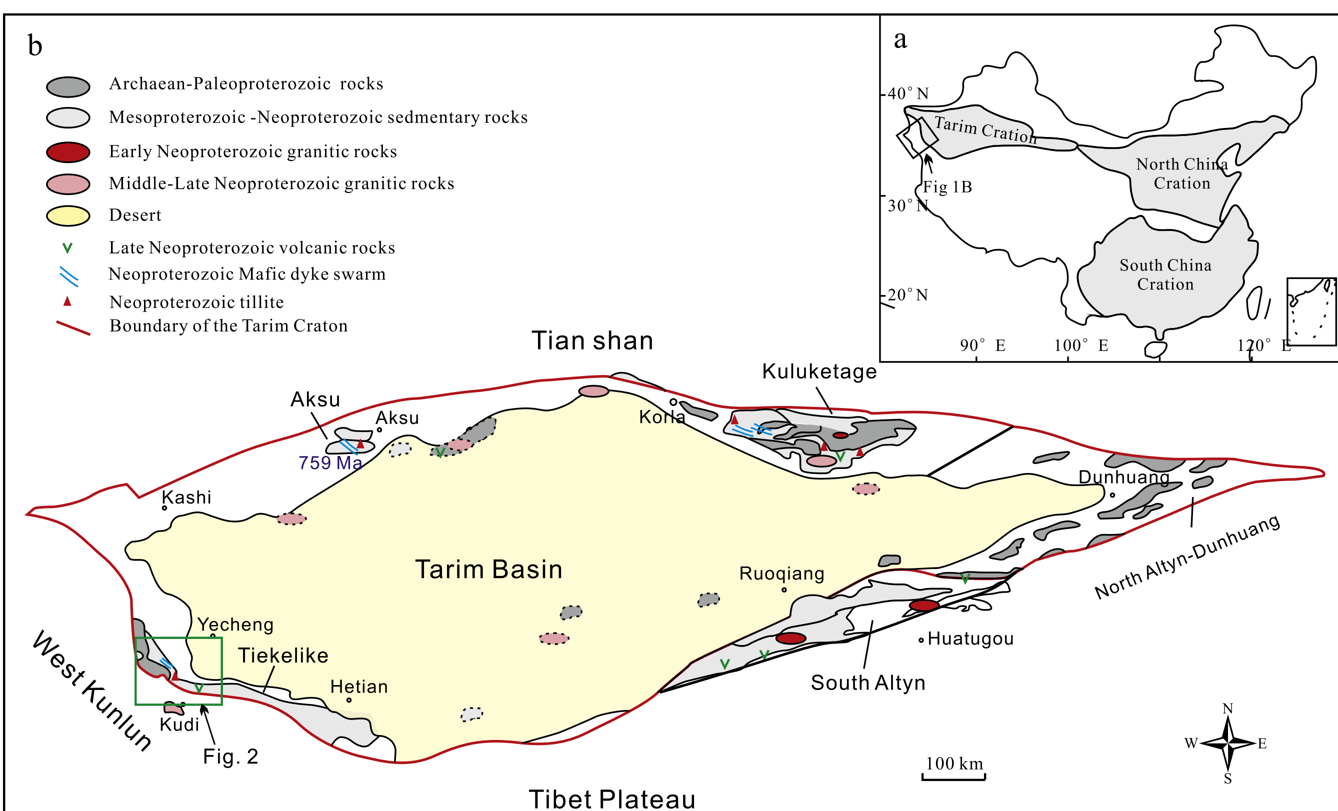

Fig. 1. (a) Simplified cratons map of China. (b) The Precambrian basement of the Tarim Craton (modified after Lu et al., 2008; Wang et al., 2015). Location of Tarim and adjoining regions and the location of major geologic units mentioned in the text are indicated in the figure. The dashed circles show the Precambrian rocks inferred from the drill holes.