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Geochronology and geochemistry of Early Mesoproterozoic meta-diabase sills from Quruqtagh in the northeastern Tarim Craton: Implications for breakup of the Columbia supercontinent

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ABSTRACT

Metadiabase sills are extensively distributed in the Astingbulake region in the central Quruqtagh block of the NE Tarim Craton. Here we report laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) zircon U–Pb ages and Hf isotopes, as well as whole rock elemental and Sr–Nd isotopic data for these Mesoproterozoic sills. Zircons from one of the mafic sills yield an emplacement age of 1470 ± 9 Ma (95% confidence, MSWD = 3.2, *n* = 23) Ma. Despite the greenschist-amphibolite facies metamorphism, most of the immobile elements provide important clues for the petrogenesis and tectonic settings of these rocks. Except for their variable fluid mobile-element contents, all the studied samples show enrichment in incompatible trace elements with no obvious Nb–Ta depletion, similar to the features of continental flood basalts and ocean island basalts (OIB). Combined with their relative higher $^{87}Sr/^{86}Sr$ (t) ratios (0.70666 to 0.70784), negative εNd(t) (−4.30 to −3.96) and εHf (t) (−5.49 to −1.13) values, we propose that the protolithic magmas were derived from the high degree partial melting of enriched continental lithospheric mantle within continental rifting settings. The ~1.5 Ga diabase sills from North Tarim corresponded to the major episode of mafic magmatism during Early Mesoproterozoic time identified from other crustal fragments of Laurentia, Siberia, Greater Congo and South China, and probably belong to one of the three major large igneous provinces associated with the breakup of the Mesoproterozoic Columbia supercontinent. Our data provide important constraints on the configuration of the Tarim Craton within the Columbia supercontinent

1. Introduction

It is generally considered that the assembly of continental fragments within Columbia – the first coherent supercontinent in Earth history – was completed through global-scale collisional events during the period 2.0–1.8 Ga (Rogers and Santosh, 2002, 2003, 2009; Zhao et al., 2002, 2003a, 2003b, 2004, 2011; Condie, 2002; Meert, 2002, 2013; Mohanty, 2012; Sears and Price, 2002; Wilde et al., 2002; Pesonen et al., 2003; Santosh et al., 2003, 2009; Hou et al., 2008; Peng et al., 2012; Ernst et al., 2008, 2013a; Roberts, 2012, 2013; Kaur et al., 2013; Nance and Murphy, 2013; Nance et al., 2013; Young, 2013). Following its final assembly at ~1.8 Ga, the supercontinent Columbia underwent long-lived (1.8–1.3 Ga), subduction-related outward growth along some of its margins, as inferred from the 1.8–1.3 Ga magmatic arcs bordering the present southern and southeastern margins of Laurentia, southern margin of Baltica, northwestern margin of Amazonia, and southern and eastern margins of the North Australian Craton (Zhao et al., 2004, 2011 and references therein). The 1.6–1.2 Ga intracontinental rift zones and anorogenic magmatism including the anorthosite-mangerite-charnockite-granite suites, rapakivi granites, kimberlites, lamproites, and carbonatites in many cratonic blocks in the world are considered to mark the beginning of the fragmentation of Columbia at ca. 1.6 Ga. The final break-up of the

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supercontinent is represented by the emplacement of 1.35–1.27 Ga mafic dike swarms in all the constituent cratonic blocks. The mafic dyke swarms serve as the piercing points where the cratonic blocks in the supercontinent can be palaeomagnetically and geologically linked (Zhao et al., 2002, 2004, 2011).

Several studies have linked the Paleoproterozoic tectonic history of the Tarim Craton with the evolution of the Columbia supercontinent, although models on the juxtaposition of Tarim craton within Columbia (Nuna) has remained equivocal (Zhao et al., 2002, 2009, 2011; Kusky et al., 2007; Kusky and Santosh, 2009; Santosh, 2010; Yakubchuk, 2008, 2010; Zhao and Cawood, 2012; Zhang et al., 2013a; Zheng et al., 2013). Of particular importance in this context is the ~1.9 Ga magmatic event recorded from the Paleoproterozoic Xingtage gneissic granites in the Quruqtagh block at the northeastern margin of the Tarim craton (Guo et al., 2003; Lu et al., 2008; Zhang et al., 2012b; Shu et al., 2011; Lei et al., 2012; Long et al., 2012; Wu et al., 2012; Ge et al., 2013a, 2013b) and from the Paleoproterozoic gneisses from the Tiekelike, North Altyn Tagh and Dunhuang block (Lu et al., 2008; Zhang et al., 2003b, 2007b, 2012c, 2013b). Most of the studies considered that the ~1.9 Ga magmatic and metamorphic events were coincident with the global-scale subduction–accretion–collision events that led to the assembly of the Paleo-Mesoproterozoic Columbia supercontinent (Lei et al., 2012; Shu et al., 2011; Long et al., 2012; Zhang et al., 2013b; Ma et al., 2013).

In recent investigations, Ma et al. (2012a,b) reported numerous detrital zircon U–Pb ages and in situ Hf isotopic analysis of Neoproterozoic and Paleozoic (meta-)sedimentary rocks from the Central Tianshan, which identified a dominant age peak at ca. 1600–1500 Ma. Similar age peak at ca. 1600–1400 Ma was also reported by Shu et al. (2011) and Rojas-Agramonte et al. (2011) from detrital zircons derived from the Tarim Craton. Therefore, the Central Tianshan was proposed to be connected with the northern part of the Tarim before Paleozoic, and the Mesoproterozoic detrital zircon age peak was attributed to a magmatic event associated with the break-up of Columbia. However, clear evidence for Mesoproterozoic mafic intrusions or volcanic rocks which would serve as the fingerprints for supercontinent breakup have seldom been reported from the Tarim Craton.

Because of the lack of reliable ages for Meso-Neoproterozoic thermo-tectonic records in the Tarim craton, the juxtaposition of this craton in relation to the assembly, configuration, and break-up of the Proterozoic supercontinents remains obscure. In this contribution, we report for the first time precise zircon geochronological and geochemical data from meta-diabase sills from the Quruqtagh block of northern Tarim Craton, offering important evidence for Mesoproterozoic mafic magmatism in this craton and its relevance on the break-up of the supercontinent Columbia.

2. Geological background

The Tarim Craton, located in northwest China and covering an area of about 600,000 km^2, is poorly studied because more than 85% of the surface of the craton is covered by desert. The craton is bound by the Tianshan, western Kunlun and central-southern Altyn Tagh mountain belts to the north, south and southeast, respectively (Fig. 1a; Lu et al., 2008; Lei et al., 2011; Zhang et al., 2012b). Several investigations related to the geological, structural, petrological, geochemical and geochronological history of the Tarim Craton were carried out in the recent years which led to the identification of five distinct Precambrian basements exposed along the margins of the craton, which include the Quruqtagh block in the northeastern margin (Guo et al., 2003; Xu et al., 2005, 2009; Lu et al., 2008; Long et al., 2010, 2011b, 2012; Shu et al., 2011; Zhang et al., 2007a, 2007b, 2009a, 2009b, 2011, 2012a, 2012b; Zhu et al., 2010, 2011; Lei et al., 2012), the Aksu block in the northwestern margin (Zhang et al., 2009a, 2009b; Zheng et al., 2010; Turner, 2012; Yong et al., 2013), the Tiekelike block in the southwestern margin (Zhang et al., 2003a, 2003b; Lu et al., 2008; Wang et al., 2012), the north Altyn Tagh block and the Dunhuang block (Mei et al., 1998; Lu and Yuan, 2003; Zhang et al., 2012a, 2013b; Wang et al., 2013) in the southeastern margin.

The approximately E–W-trending Quruqtagh block (also spelled as Kuruqtagh or Kuluktage), is located in the northeast part of the Tarim craton, where Precambrian rocks are widely exposed (Fig. 1a). The block is bound by the Korla–Xinger fault to the north and the Xingdi fault to the south (Shu et al., 2011; Fig. 1b). Both faults extend roughly E–W for hundreds of kilometers (Fig. 1b). The Xingdi fault also shows a clear linear structure in the satellite image. The Quruqtagh block is composed of an older metamorphic crystalline basement and a younger sedimentary cover consisting of strata from the middle Neoproterozoic to Phanerozoic (Gao et al., 1993; Feng et al., 1995; Hu et al., 2000; Guo et al., 2003; Lu et al., 2008; Shu et al., 2011).

Archean rocks are exposed mainly in the central part of the Quruqtagh block, where Neoarchean granitic gneiss, considered to have been derived from TTG (tonalite-trondhjemite-granodiorite) and minor supracrustal rocks, are preserved (Hu and Rogers, 1992; Lu, 1992; Lu et al., 2008). Recent zircon U–Pb geochronology of the TTG gneiss near Korla and the Tuoge complex yielded two populations of late Neoarchean weighted mean ages, indicating that their protoliths were formed in the late Neoarchean (Long et al., 2010, 2011b). These Archean rocks in the complex are referred to as the Tuoge complex, consisting mainly of TTG gneisses with amphibolite enclaves, calc-alkaline granites and high Ba-Sr granites (Zhang et al., 2012b), among which the TTG rocks and calc-alkaline granites were emplaced during 2.65 Ga to 2.50 Ga (Lu, 1992; Long et al., 2010, 2011b; Shu et al., 2011; Zhang et al., 2012b).

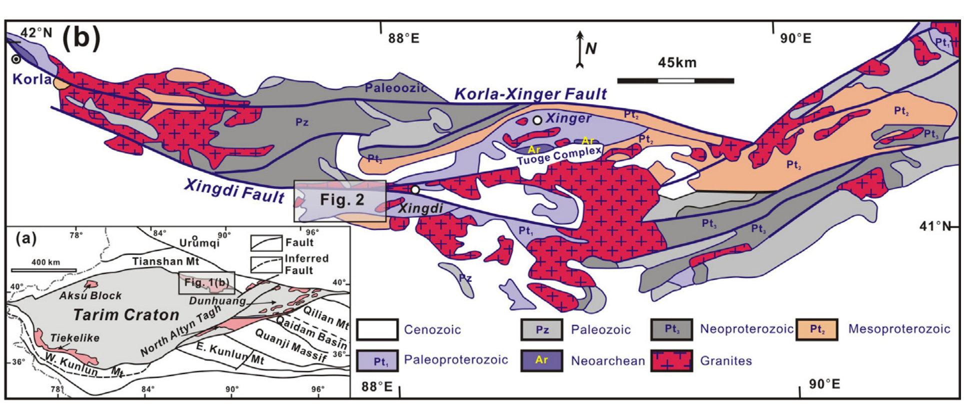

Fig. 1. (a) Geological map showing the spatial distribution of Precambrian rocks in the Tarim Craton (Lu et al., 2008; Zhao and Cawood, 2012) (b) Simplified regional geological map of the Quruqtagh block, northern Tarim Craton (modified after Long et al., 2010).