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Detrital zircon provenance constraints on the initial uplift and denudation of the Chinese western Tianshan after the assembly of the southwestern Central Asian Orogenic Belt

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ABSTRACT

U–Pb and Lu–Hf isotopic data of detrital zircons from late Paleozoic and Mesozoic strata along the southern flank of the Chinese western Tianshan enable to identify provenance changes and reconstruct early stage uplift and denudation history of the Tianshan range. Detrital zircons from Permian and Early–Middle Triassic siliciclastic rocks show two prominent age populations at 500–390 Ma and 310–260 Ma, and subordinate Precambrian ages at ~2.5 Ga, 2.0–1.7 Ga, 1.2–0.9 Ga and 900–600 Ma, with rare ages between 390 and 310 Ma. These characteristics and zircon $\varepsilon_{Hf}(t)$ data consistently suggest a sediment source predominantly from the Tarim Craton, rather than the Central Tianshan–Yili Block. In contrast, Late Triassic to Cretaceous strata additionally contain abundant 390–310 Ma and 260–220 Ma detrital zircons, implying multiple source regions from the Central Tianshan–Yili Block, Tarim Craton, and Western Kunlun Orogen. A significant switch of sedimentary provenances occurred in the mid-Triassic and is consistent with contemporaneous change of paleocurrent directions and the onset of intense tectonothermal events in the broad region of the Chinese western Tianshan and Kyrgyz Tianshan. These data collectively indicate that the significant surface uplift and denudation of the Tianshan range were probably initiated in the mid-Triassic (~240 Ma) after the assembly of the southwestern Central Asian Orogenic Belt. This uplifting event represents an intracontinental orogeny most likely in response to the collision between the Qiangtang Block and southern Eurasia, following the closure of the western part of the Paleo-Tethys Ocean.

1. Introduction

The Tianshan mountain belt extends east–west along the southwestern part of the Central Asian Orogenic Belt (CAOB) and represents a composite orogenic collage assembled by the amalgamation of the Tarim–Karakum cratons with several tectonic domains to the north, including the Central Tianshan (CTS), Kazakhstan–Yili, and Junggar blocks (Fig. 1) (Xiao et al., 2004, 2013; Charvet et al., 2011; Gao et al., 2011; Han et al., 2011, 2015; Wang et al., 2011; Wilhem et al., 2012; Xiao and Santosh, 2014; Zhang et al. 2015a, 2015b, 2016). The South Tianshan (STS) Orogenic Belt (Fig. 1a, c), and the Solonker suture zone to further east (Fig. 1a), record Proterozoic to Paleozoic accretionary history of the Paleo-Asian Ocean and mark the site of final collision of the Tarim and North China cratons with the CAOB during late Paleozoic and early Mesozoic time (Şengör et al., 1993; Jahn et al., 2000, 2004; Khain et al., 2003; Xiao et al., 2003, 2009, 2015; Jahn, 2004; Windley et al., 2007; Wilhem et al., 2012; Eizenhöfer et al., 2014, 2015a, 2015b; Kröner et al., 2014; Safonova and Santosh, 2014; Li et al., 2015; Liu et al., 2015; J. Zhang et al., 2015; Han et al., 2016a).

Despite numerous studies in the western Tianshan region, there is still much debate about the timing of final collision between the Tarim Craton and the CTS–Yili Block, with competing tectonic models suggesting collision time in the late Permian to Triassic (e.g., Li et al., 2005a; Y.J. Li et al., 2010; Zhang et al., 2007a; Xiao et al., 2013), or in the late Carboniferous or earlier (e.g., Charvet et al., 2011; Gao et al., 2011; Han et al., 2011, 2016b; Wang et al., 2011; Klemd et al., 2015). Another relevant and important controversy is the timing of initial uplift and denudation of the western Tianshan range after the amalgamation of the southern CAOB. Some authors suggested that this range was firstly uplifted in the Early Cretaceous or even later (Yin et al., 1998; Q.C. Wang et al., 2009), whereas others proposed significant uplifting stages in the Triassic (Hendrix et al., 1992) or in the late Carboniferous (Carroll et al., 2001). Triassic-age depositional and tectonothermal events were intensive in the western Tianshan region, according to recent sedimentological studies and thermochronological data (e.g., Hendrix et al., 1992, 1994; Dumitru et al., 2001; Jolivet et al., 2010; Glorie and De Grave, 2015). Therefore, how to interpret these events and

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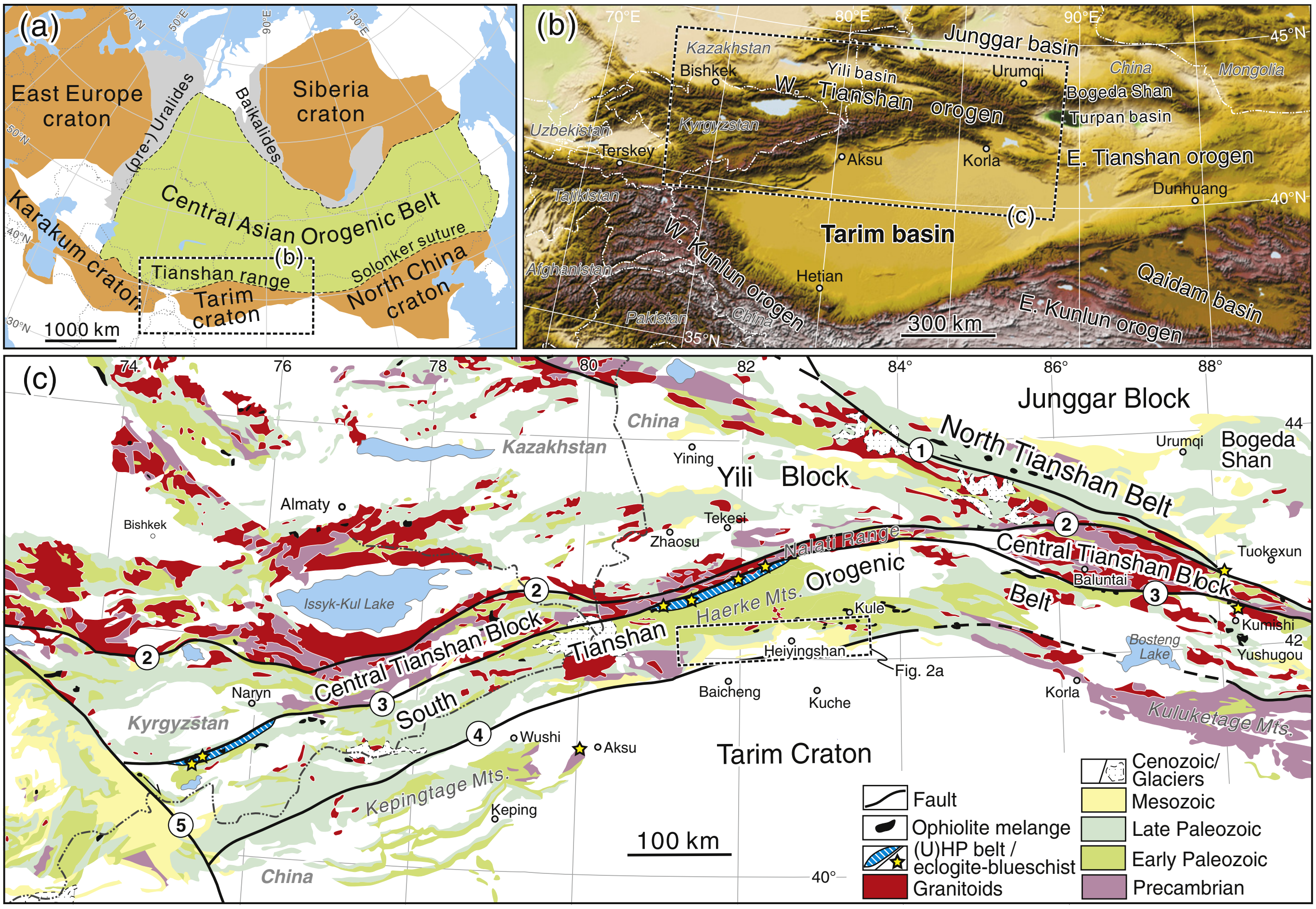

Fig. 1. (a) Tectonic outline of the Central Asian Orogenic Belt and surrounding regions (modified after Şengör et al., 1993; Windley et al., 2007; Wilhem et al., 2012). (b) Topographic map of the Tarim basin and surrounding mountain belts (from http://www.ngdc.noaa.gov/mgg/global/). (c) Schematic geological map of the northern part of the Tarim Craton and the western part of the Tianshan range (modified after H.L. Wang et al., 2007; Gao et al., 2009; Xiao et al., 2013). Major faults: (1) North Tianshan Fault, (2) Nikolaev Line–North Nalati Fault, (3) Atbashi–Inylchek–South Nalati Fault, (4) North Tarim Fault, and (5) Talas–Ferghana Fault.

reconcile current data and observations is crucial to clarify the above controversies.

Sedimentary provenance analysis based on detrital zircon age and Hf data has been shown to be powerful in tracing source regions of detritus and reconstructing tectonic evolution and mountain-building processes (e.g., Cawood et al., 2012, 2013; DeCelles et al., 2014; Gehrels, 2014). In this study, we present new and compiled detrital zircon U–Pb age and Hf isotopic data of the Permian and Mesozoic clastic successions in the southern piedmont of the Chinese western Tianshan to reveal the change of sedimentary provenances through time. These data, in combination with stratigraphic record and tectonothermal evidence, provide important constraints on the amalgamation time of this region and the early stage uplift and denudation history of the western Tianshan.

2. Geological background

2.1. Regional geology

The Tianshan orogenic belt occurs as a series of mountainous ranges extending latitudinally for over 2500 km in central Asia, across the borders of China, Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan (Fig. 1b). This study places emphasis mainly on the region of Chinese western Tianshan and partially Kyrgyz Tianshan, with a longitude range of ca. 75°E to 90°E. Based on geological records, especially the occurrence of ophiolitic mélanges and (ultra)high-pressure ((U)HP) metamorphic suites, this region is subdivided into the South Tianshan (STS) Orogenic Belt, the CTS–Yili Block, and the North Tianshan Belt, by major faults and Paleozoic-age suture zones (Fig. 1c) (Windley et al., 1990; Gao et al., 2011; Han et al., 2011; Xiao et al., 2013).

The Tarim Craton to the south of the Tianshan is roughly equivalent to the Tarim Basin (Fig. 1b) and has an Archean to early Neoproterozoic metamorphic basement, which was stabilized by the Tarim Orogeny occurring in the early Neoproterozoic (e.g., Lu et al., 2008; Zhao and Cawood, 2012). The middle Neoproterozoic to Phanerozoic cover overlying the basement is dominated by carbonate–siliciclastic sedimentary successions. Ca. 470–390 Ma granitic intrusions have been discovered in the Kuluketage and Altyn areas (e.g., Wu et al., 2007; Lin et al., 2013; Ge et al., 2014). Early Permian magmatism was widespread in the craton and characterized by bimodal magmatic suites, which are attributed to mantle plume activities beneath the Tarim cratonic lithosphere (e.g., Zhou et al., 2009; Xu et al., 2014).

The STS Orogenic Belt is separated from the Tarim Craton by the North Tarim Fault (Fig. 1c), a thrust front along the southern margin of the mountainous region. The STS Belt consists mainly of Paleozoic low-grade and unmetamorphosed carbonates and siliciclastic rocks, with Mesozoic–Cenozoic clastic successions occurring along its southern margin. Recent detrital zircon U–Pb–Hf data of the Paleozoic strata in the STS region suggest that this region was connected to the northern margin of the Tarim Craton during Paleozoic time (Han et al., 2016b). A linear belt containing ophiolitic mélanges and (U)HP metamorphic suites occurs along the northern margin of the STS Belt (Fig. 1c) and represents the relics associated with the mid- to late Paleozoic evolution of