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Ages and Hf isotopes of detrital zircons from Paleozoic strata in the Chagan Obo Temple area, Inner Mongolia: Implications for the evolution of the Central Asian Orogenic Belt

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ABSTRACT

The Central Asian Orogenic Belt (CAOB), as one of the largest accretionary orogens in the world, was built up through protracted accretion and collision of a variety of terranes due to the subduction and closure of the Paleo-Asian Ocean in the Neoproterozoic to Early Mesozoic. Located in the Uliastai continental margin of the southeastern CAOB, the Chagan Obo Temple area is essential for understanding the tectonic evolution of the southeastern part of the CAOB and its relation with the "Hegenshan Ocean". In this study, detrital zircon U-Pb geochronology coupled with Hf isotopic analysis was performed on Paleozoic sedimentary strata in this area. Most detrital zircons from the studied samples possess oscillatory zoning and have Th/U ratios of 0.4-1.73, indicative of an igneous origin. Detrital zircons from the Ordovician to Devonian sedimentary strata yield a predominant age group at 511-490 Ma and subordinate age groups at 982-891 Ma, 834-790 Ma and ~574 Ma, and have a large spread of $\varepsilon_{Hf}(t)$ values (-20.77 to +16.94). Carboniferous and Early Permian samples yield zircon U-Pb ages peaking at ~410 Ma and ~336 Ma, and have dominantly positive $\varepsilon_{Hf}(t)$ values (+1.30 to +14.86). Such age populations and Hf isotopic signatures match those of magmatic rocks in the Northern Accretionary Orogen and the Mongolian arcs. A marked shift of provenance terranes from multiple sources to a single source and Hf isotope compositions from mixed to positive values occurred at some time in the Carboniferous. Such a shift implies that the Northern Accretionary Orogen was no longer a contributor of detritus in the Carboniferous to Early Permian, due to the opening of the "Hegenshan Ocean" possibly induced by the slab rollback of the subducting Paleo-Asian Ocean.

1. Introduction

The Central Asian Orogenic Belt (CAOB), also termed the Altaids, is one of the largest accretionary orogenic collages in the world. It is bounded to the north by the Siberian craton, to the west by the East European Block and to the south by the Tarim and North China cratons (Fig. 1). (Zonenshain et al., 1990; Mossakovsky et al., 1993; Sengör et al., 1993; Jahn et al., 2000; Badarch et al., 2002; Xiao et al., 2003, 2004; Jahn, 2004a; Jahn et al., 2004b; Briggs et al., 2007; Windley et al., 2007; Jian et al., 2008; Xiao et al., 2009a, 2009b, 2010, 2013; Eizenhöfer et al., 2014; Xiao and Santosh, 2014; Xiao et al., 2015; Eizenhöfer et al., 2015a, 2015b). This vast orogen was built up through interplay of a series of tectonically related island arcs, fore-arc or back-arc basins, ophiolitic belts, blueschist belts, and remnant microcontinents, resulting from Neoproterozoic to Mesozoic oceanic subduction, closure, accretion and collision of allochthonous microcontinents. (Wang and Liu, 1986; Shao, 1989; Tang, 1990; Sengör and Natal'in, 1996a, 1996b; Xu and Chen, 1997; Xiao et al., 2003, 2004; Li, 2006; Xiao et al., 2009a, 2009b, 2010; Kröner et al., 2011; Xu et al., 2013; Zhao et al., 2013; Xiao and Santosh, 2014; Han et al., 2015; Xiao et al., 2015; Han et al., 2016a, 2016b). The accretionary and collisional processes, starting at ~750 Ma coevally with the breakup of Rodinia and possibly lasting till early Triassic (Eizenhöfer et al., 2014), resulted in (1) the closure of the Paleo-Asian Ocean (PAO), (2) the assembly of Eurasia, including the amalgamation of the Tarim and North China blocks in the south, the East Europen and Siberian blocks in the north, and also microcontinents, terranes and arcs in or between blocks, and (3) considerable Phanerozoic juvenile crustal growth (Sengör et al., 1993; Heubeck, 2001; Xiao et al., 2003; Torsvik and Cocks, 2004; Xiao et al., 2004, 2009a, 2009b, 2010; Han et al., 2011; Xiao et al., 2013; Eizenhöfer et al., 2014; Xiao and Santosh, 2014; Han et al., 2015; Xiao et al., 2015; Zhu et al., 2015; Zhang et al., 2015a; Han et al., 2016a, 2016b).

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Fig. 1. Tectonic subdivision of central and East Asia showing the Central Asian Orogenic Belt and surrounding major cratons (modified after Li, 2006). A square outlines the position of Fig. 2.

Despite extensive investigations, many unresolved issues still remain, especially regarding when and how the Paleo-Asian Ocean subducted and closed to form the CAOB. Available models emphasizing different accretionary processes include: (1) progressive subduction and accretion associated with the closure of a single major ocean (e.g., Sengör et al., 1993; Sengör and Natal'in, 1996a, 1996b; Yakubchuk, 2004), (2) accretion of accretionary complexes onto microcontinents or within oceanic domains (e.g., Mossakovsky et al., 1993; Fedorovskii et al., 1995), and (3) punctuated subduction and collision of several microcontinents and arcs with bidirectional orogenic polarity (e.g., Coleman, 1989; Mossakovsky et al., 1993; Filippova et al., 2001; Xiao et al., 2003; Xiao et al., 2004; Briggs et al., 2007; Windley et al., 2007; Kelty et al., 2008; Xiao et al., 2009a, 2009b, 2010). In addition, controversy has also surrounded the timing of final closure of the Paleo-Asian Ocean, with some researchers invoking that the collision between North China and Siberia occurred during the late Devonian to early Carboniferous (e.g., Tang, 1990; Shao, 1991; Xu and Chen, 1997), whereas other workers, based on the recognition of Permian calc-alkaline magmatism, paleontology and ophiolites, argue that the intervening ocean between the North China craton (NCC) and the South Mongolian microcontinent was not closed until the late Permian or early Triassic (e.g., Wang and Liu, 1986; Hsü et al., 1991; Sengör and Natal'in, 1996a, 1996b; Xiao et al., 2003, 2004; Miao et al., 2008; Xiao et al., 2009a, 2009b, 2010, 2013; Eizenhöfer et al., 2014; Xiao et al., 2015; Eizenhöfer et al., 2015a, 2015b).

Compared with the western segment of the CAOB, several fundamental questions remain ambiguous in the eastern part due to lack of insufficient studies, especially on the Inner Mongolia terrane in China. The Inner Mongolia terrane occupies an intermediate position between Siberia and North China (Fig. 1). It records wealthy information