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Late Paleozoic provenance shift in the south-central North China Craton: Implications for tectonic evolution and crustal growth

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ABSTRACT

U–Pb geochronologic and Hf isotopic results of seven sandstones collected from Late Carboniferous through Early Triassic strata of the south-central part of the North China Craton record a dramatic provenance shift near the end of the Late Carboniferous. Detrital zircons from the Late Carboniferous sandstones are dominated by the Early Paleozoic components with positive $\varepsilon_{Hf}(t)$ values, implying the existence of a significant volume of juvenile crust at this age in the source regions. Moreover, there are also three minor peaks at ca. 2.5 Ga, 1.87 Ga and 1.1–0.9 Ga. Based on our new data, in conjunction with existing zircon ages and Hf isotopic data in the North China Craton (NCC), Central China Orogenic Belt (CCOB) and Central Asian Orogenic Belt (CAOB), it can be concluded that Early Paleozoic and Neoproterozoic detritus in the south-central NCC were derived from the CCOB. Zircons with ages of 1.9–1.7 Ga were derived from the NCC. However, the oldest components can't be distinguished, possibly from either the NCC or the CCOB, or both. In contrast, detrital zircons from the Permian and Triassic sandstones are characterized by three major groups of U–Pb ages (2.6–2.4 Ga, 1.9–1.7 Ga and Late Paleozoic ages). Specially, most of the Late Paleozoic zircons show negative $\varepsilon_{Hf}(t)$ values, similar to the igneous zircons from intrusive rocks of the Inner Mongolia Paleo-Uplift (IMPU), indicating that the Late Paleozoic detritus were derived from the northern part of the NCC. This provenance shift could be approximately constrained at the end of the Late Carboniferous and probably hints that tectonic uplift firstly occurred between the CCOB and the NCC as a result of the collision between the South and North Qinling microcontinental terranes, and then switched to the domain between the CAOB and the NCC. Additionally, on the basis of Lu–Hf isotopic data, we reveal the pre-Triassic crustal growth history for the NCC. In comparison among the three crustal growth curves obtained from modern river sands, our samples, and the Proterozoic sedimentary rocks, we realize that old components are apparently underestimated by zircons from the younger sedimentary rocks and modern river sands. Hence, cautions should be taken when using this method to investigate growth history of continental crust.

1. Introduction

In general, tectonic uplift regions, e.g., mountain belts, and adjacent subsidence regions, e.g., basins, are often temporally and spatially linked. However, since these uplift regions are also usually located in active tectonic settings, the evident features of tectonic uplift areas are easily removed by erosion or tectonism, and obscured by later multiple magmatism or metamorphism. In comparison, materials eroded from the uplift areas and subsequently deposited in adjacent basin(s), can probably preserve an invaluable archive of the evolution of the uplift areas. Hence, study of the erosive product of uplift areas contributes to the understanding of the paleogeographic evolution as well as the causes (e.g., Dickinson and Suczek, 1979; Najman, 2006; Cawood et al., 2007).

Zircon, as a ubiquitous trace mineral in clastic sedimentary rocks, possesses nearly the highest closure temperature of the U–Th–Pb system, which makes it to be capable of remaining isotopically closed through extended periods of high-grade metamorphism or even partial melting of the host rock (Lee et al., 1997; Cherniak and Watson, 2001). Furthermore, multiple studies have also shown that the initial $^{176}Hf/^{177}Hf$ value, once incorporated into the zircon lattice during growth, is not modified by processes that may disturb or reset the U–Pb isotopic system (Kinny and Maas, 2003). The combination of U–Pb and Lu–Hf isotopic techniques makes it possible to determine for each grain not only the age but the nature and genesis of the host magma, either crustal or juvenile mantle. For these reasons, U–Pb dating and Hf isotopic analyses of detrital zircons obtained from clastic sedimentary rocks are widely used in studies of determining maximum age of stratigraphic successions, provenance characteristics, paleogeographic reconstructions and growth of continents (Fedo et al., 2003; Iizuka et al., 2005; Veevers et al., 2005; Yang et al., 2009; Iizuka et al., 2010; Ying et al., 2011).

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The tectonic evolution of the North China Craton (NCC) during the Late Paleozoic is closely related to the progressive subduction of the Paleo-Asian Ocean to the north (e.g., Zonenshain et al., 1990; Dobretsov et al., 1995; Buslov et al., 2001; Xiao et al., 2003; Li, 2006; Safonova, 2009; Xiao et al., 2009) and the Palaeo-Tethys Ocean to the south (Dong et al., 2011b and references therein) (Fig. 1). The progressive subduction of the Paleo-Asian Ocean and accretion of ophiolitic, island-arc, back-arc, active margin, and continental terranes formed a remarkable orogenic belt: the Central Asian Orogenic Belt (CAOB) (e.g., Sengör and Natal'in, 1996; Xiao et al., 2003; Kovalenko et al., 2004; Kröner et al., 2007; Windley et al., 2007; Xiao et al., 2009; Safonova et al., 2011). Similarly, the subduction of the Paleo-Tethys Ocean and the collision between the North China Craton (NCC) and the Yangtze Craton (YZ) formed the Central China Orogenic Belt (CCOB) (e.g., Mattauer et al., 1985; Kröner et al., 1993; Gao et al., 1995; Zhang et al., 1997; Ratschbacher et al., 2003, 2006). Naturally, these two orogenic belts could offer materials for adjacent and internal basins of the NCC. In recent years, U–Pb dating and Hf isotopic analysis of detrital zircons has been widely used in reconstructing the paleogeography of the northern part of the NCC from the Late Paleozoic to Mesozoic (e.g., Yang et al., 2006; Li et al., 2010). In contrast, our knowledge of the paleogeographic evolution as well as the causes for the south-central part of the NCC during the Late Paleozoic is poorly understood. Furthermore, the interactions between these two orogenic belts (the CAOB and CCOB) and the NCC during the Late Paleozoic, have not been systematically explored by any previous work. In addition, Yang et al. (2009) and Ying et al. (2011) studied the crustal growth curve of the NCC using detrital zircons from modern river sands and Proterozoic strata, respectively. However, whether these two crustal growth curves are suitable for detrital zircons from Phanerozoic clastic sedimentary strata has not been verified.

To detect the provenance, investigate tectonic evolution and reveal the crustal growth history of the NCC, we conducted detrital zircon analysis in the southern-central part of the NCC. A set of detrital zircon U–Pb ages and in-situ Hf isotope data of the Qinshui Basin located in the southern-central part of the Trans-North China Orogen was obtained. The data set is used to detect and trace sediment provenance of the Qinshui Basin during the Late Paleozoic. In addition, based on the data set, we reveal the pre-Triassic continental crustal growth pattern of the NCC.

2. Geological setting and samples

Traditionally, the NCC has been considered to consist of the West Block, Eastern Block and the Trans-North China Orogen (e.g., Zhao et al., 2001, 2009; Kusky, 2011 and references therein; Fig. 1), although the timing and tectonic mechanism of formation of the Trans-North China Orogen is still controversial (Zhao et al., 2002; Kusky and Li, 2003; Zhao et al., 2006; Kusky, 2011; Zhai and Santosh, 2011). The basement of the NCC consists of variably exposed Archean to Paleoproterozoic rocks, unconformably overlain by the Mesoproterozoic unmetamorphosed volcanic–sedimentary successions and Phanerozoic cover. Early Paleozoic strata are represented by Cambrian–Middle Ordovician deposits dominated by epicontinental carbonate sediments, whereas a Late Carboniferous to Early Permian alternating marine and terrestrial sequence is characterized by coal-bearing strata, overlain by the Late Permian to Triassic red beds and conglomerates. Silurian, Devonian and part of the Early

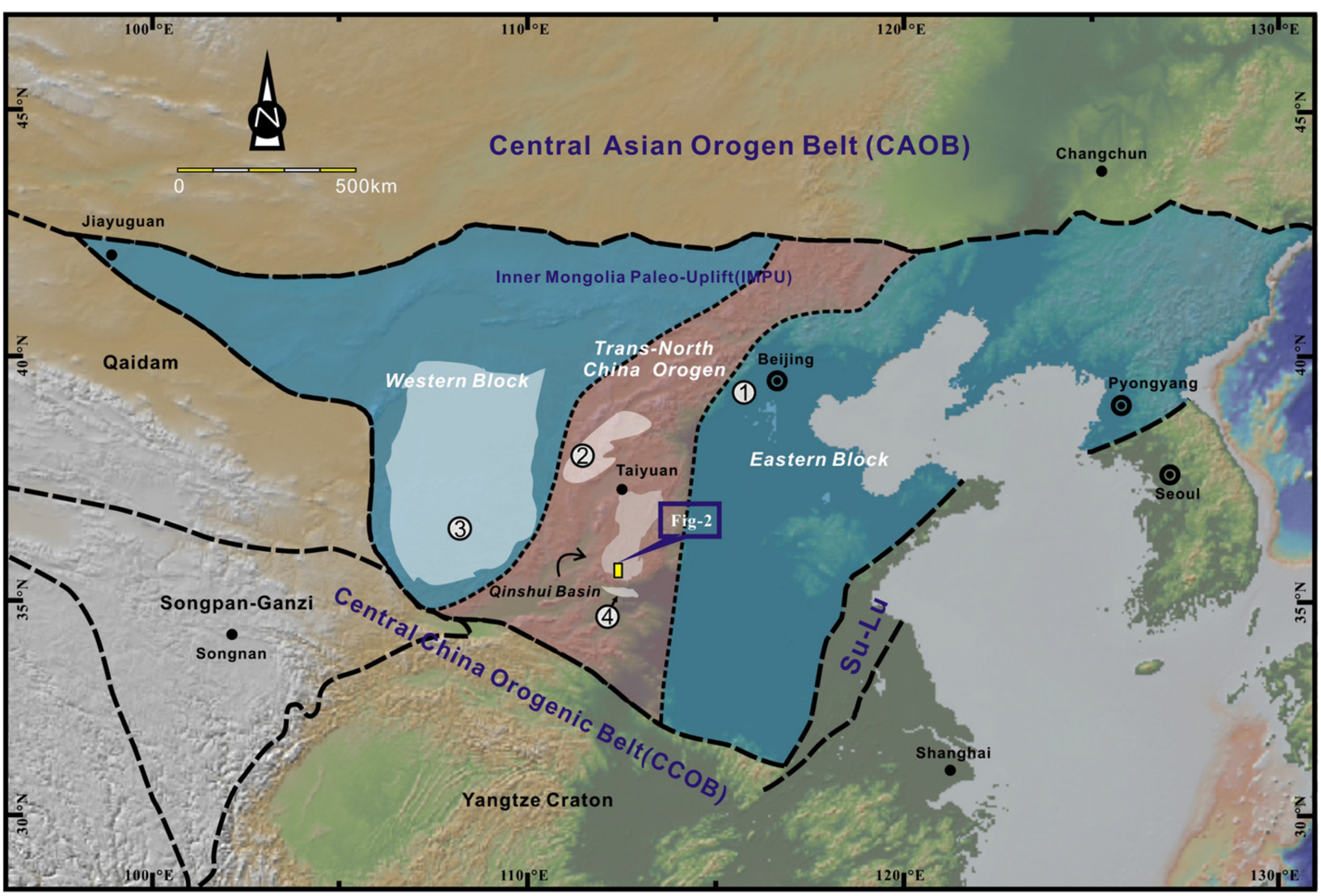

Fig. 1. Geological sketch map of North China Craton and study area, 1 = Xishan area; 2 = Ningwu–Jingle Basin; 3 = Ordos Basin; and 4 = Jiyuan Basin. Modified after Zhao et al. (2001, 2005).