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Detrital zircon fingerprints link western North China Craton with East Gondwana during Ordovician

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ABSTRACT

The tectonic affinity of the North China Craton (NCC) in the early Paleozoic paleogeographic reconstructions of the Gondwana supercontinent remains controversial. Here we present new detrital zircon U–Pb age data from Middle (Sandaokan Formation) to Upper Ordovician (Lashizhong Formation) sandstone deposits from biostratigraphically well–constrained strata in the Zhuozishan Mountain area, western NCC, to explore the link between NCC and Gondwana. The detrital zircon age spectra from the Sandaokan Formation range in age from 1684 to 2905 Ma with peaks of Neoarchean (~2.5 Ga) and Paleoproterozoic (~1.83 and ~1.96 Ga), and display age distribution similar to that of the Precambrian basement of the NCC. The Lashizhong Formation contains zircons ranging in age from 3626 to 488 Ma, with six main age peaks (1000–900 Ma, 2600–2400 Ma, 900–700 Ma, 700–500 Ma, 1300–1100 Ma and 2000–1500 Ma).The grains represent a record of the Grenville and Pan-African orogenic events, in striking contrast to those for the Sandaokan Formation. The age spectra of the Lashizhong Formation are similar to those from crustal blocks associated with eastern Gondwana. Our results suggest that the western part of the NCC might have been linked with the East Gondwana, rather than being an isolated continent block in the paleo–Pacific, as proposed in current models. The detrital zircon age populations relative to the depositional ages, sandstone lithofacies, sedimentary structures, and paleogeography suggest that the Sandaokan Formation was deposited in a passive continental margin setting, whereas the Lashizhong Formation formed in a collisional setting, which suggests an orogenic belt or suture zone located to the west of the NCC. The significant difference in provenances between the two formations within a short interval (ca. 6 Ma) might suggest a newly identified tectonic shift at ca. 458 Ma, followed by the northwestern margin transforming into a possible foreland basin stage between the NCC and the eastern Gondwana.

1. Introduction

The paleogeographic configuration of continental blocks around the eastern segment of the late Neoproterozoic supercontinent Gondwana has been addressed in many studies (e.g., Collins and Pisarevsky, 2005; Meert and Lieberman, 2008; Santosh et al., 2009; Nance et al., 2014), but the location of the North China Craton (NCC) and its history of interaction with the Gondwana fragments during the Paleozoic are poorly constrained (Meert, 2014; Han et al., 2015; Myrow et al., 2015). Contrasting models have been proposed by different workers for the paleogeography of the NCC in relation to Gondwana ranging from Gondwana margin affiliation (Li and Powell, 2001; Zhao et al., 2007; Goldman et al., 2011; McKenzie et al., 2011a; Metcalfe, 2013; Han et al., 2015; Myrow et al., 2015) to locations that were unconnected to the margin of this supercontinent during early Paleozoic (Santosh et al., 2009; Wilhem et al., 2012; Cocks and Torsvik, 2013; Xu et al., 2013; Burrett et al., 2014; Yu et al., 2015; Cai et al., 2016; Wang et al., 2016). However, recent detrital zircon, paleomagnetic, stratigraphic, and paleobiogeographic evidence suggests that the NCC had a close affinity to the northern East Gondwana margin during the middle Cambrian through Ordovician (Zhao et al., 2007; McKenzie et al., 2011a; Metcalfe, 2013; Hally and Paterson, 2014; Han et al., 2015; Myrow et al., 2015). Based on detrital zircon U–Pb ages with species–level polymerid trilobite biogeography, McKenzie et al. (2011a) suggested that the southern margin of the NCC was tectonically attached to the northern margin of East Gondwana and that the western NCC (the Ordos region) was isolated from Gondwana–derived sediment during the Cambrian. The detrital zircon spectra from upper Proterozoic

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to late Middle Ordovician (Darriwilian) strata collected from the western NCC (Darby and Gehrels, 2006; Myrow et al., 2015) display prominent ages at ca. 1.8–2.3 Ga with a distinctive profile from that of other regions of Gondwana (Squire et al., 2006; Myrow et al., 2010), seemingly supporting the view that the NCC was isolated from Gondwana during the Cambrian–Ordovician. However, a revised paleogeographic reconstruction by Myrow et al. (2015), based on the timing and duration of the Cambrian–Ordovician unconformity in the western NCC comparable with those in the North Indian regions indicated a potential paleogeographic link of the NCC to the northern Indian margin of the East Gondwana. This model suggested that the western NCC (the Inner Mongolian region) was likely an along–strike continuation of the northern Indian continental margin during the latest Cambrian, which needs to be tested by further studies.

The appropriate placement of the NCC in the reconstruction and regional paleogeography of Gondwana remains a challenging topic (Metcalfe, 2013). Whether or not the NCC was juxtaposed at the northern margin of Gondwana during the Ordovician remain unresolved, partly because of the lack of adequate sediment provenance information and paucity of systematic and complete geochronological data on Ordovician strata in the NCC. In this study, we report laser ablation inductively coupled mass spectrometry (LA–ICP–MS) zircon U–Pb ages from the Middle Ordovician Sandaokan Formation and Upper Ordovician Lashizhong Formation in Zhuozishan Mountain area, which is located in the northwestern NCC (Fig. 1). The results, coupled with recently published species level biogeographic analysis of conodonts, are used to constrain the location of the NCC with respect to Gondwana, thus offering insights the tectonic setting of the western margin of the craton during the Ordovician.

2. Geological background

The NCC is one of the oldest cratonic blocks in the world, containing rocks as old as ~3.85 Ga (Liu et al., 1992, 2008; Liou et al., 2014), and a prolonged early Precambrian crustal evolution history (Zhai and Santosh, 2011; Zhao and Zhai, 2013), including major Neoarchean micro–continent amalgamation and craton building (e.g., Santosh et al., 2015a; Yang et al., 2016). The craton is bound by the Qilian Orogenic Belt to the west and southwest (Song et al., 2013; Dong and Santosh, 2016), the southern branch of the Central Asian Orogenic Belt to the north (Xiao et al., 2003), and the Qinling–Dabie and Su–Lu high–pressure metamorphic belts to the south and southeast (Shi et al., 2013).Traditionally, the basement of the NCC has been divided into the Eastern and Western Blocks, separated by the Trans–North China Orogen with the EW–trending Khondalite Belt (or Inner Mongolia Suture Zone, Santosh, 2010) separating the Western Block into the Yinshan Block in the north and the Ordos Block in the south, and the Jiao–Liao–Ji Belt dissecting the Eastern Block into the Longgang Block and the Langrim Block (e.g., Zhao et al., 1998, 2001, 2005; Santosh et al., 2007, 2012; Zhao and Cawood, 2012; Zhao and Zhai, 2013; Zheng et al., 2013; Fig. 1). However, recent studies indicate that the NCC is a collage of several Archean microblocks and that the final cratonization involved protracted Paleoproterozoic subduction–accretion collision events (e.g., Zhai and Santosh, 2011; Santosh et al., 2015b; Yang et al., 2016).

Mesoproterozoic to Cenozoic unmetamorphosed strata overlie Archean to Paleoproterozoic metamorphic basement of the NCC. During the late Proterozoic and early Paleozoic, passive margins developed on all sides of the NCC (Sun et al., 1989; Yin and Nie, 1996; Meng et al., 1997), and the Cambrian to Middle Ordovician strata of the NCC are dominated by siliciclastic and carbonate successions (Zhao et al.,

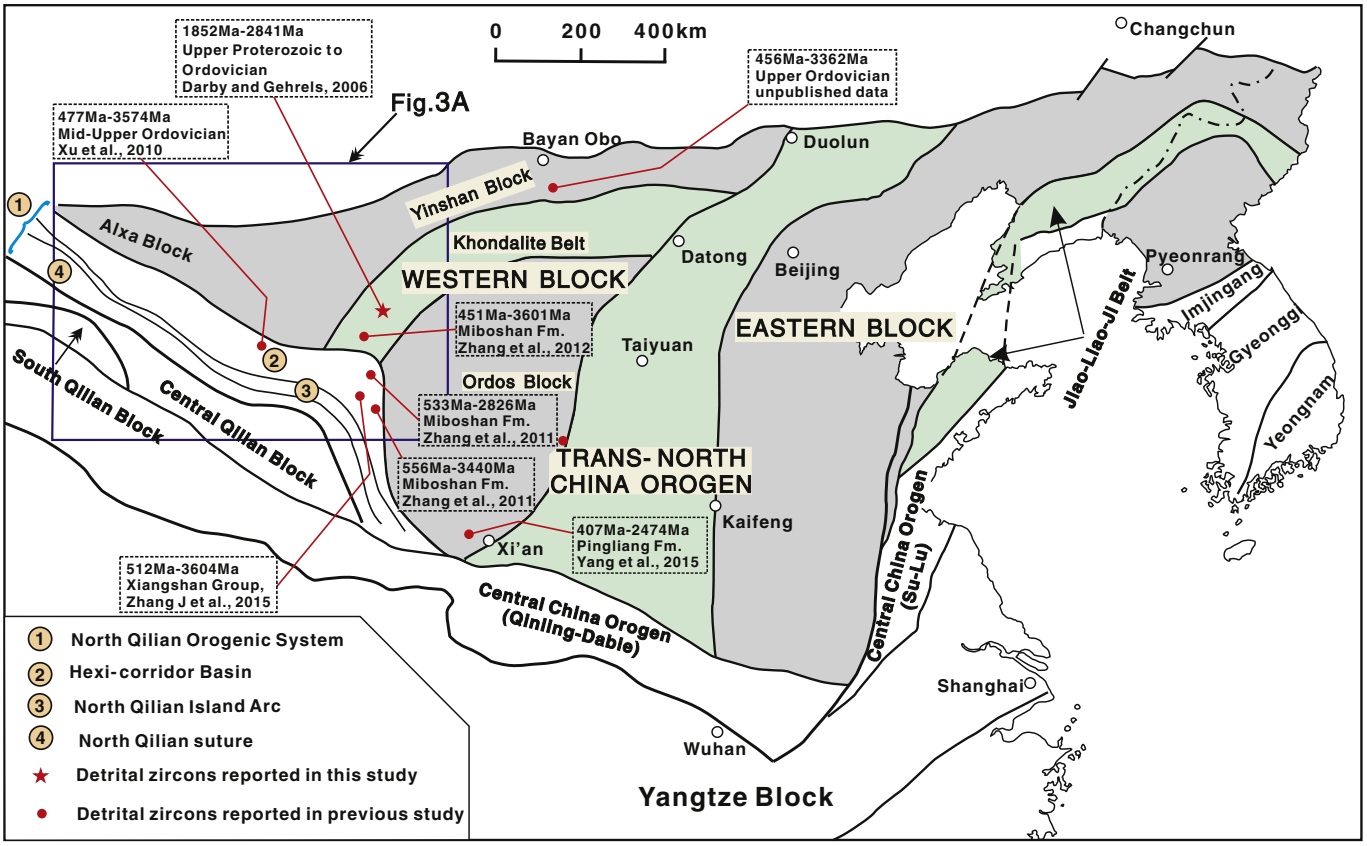

Fig. 1. Tectonic subdivision of the North China Craton (after Zhao et al., 2005) and the distribution of detrital zircons reported mainly from Ordovician strata.