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Provenance of Late Carboniferous bauxite deposits in the North China Craton: New constraints on marginal arc construction and accretion processes

Qingfei Wang *, Jun Deng, Xuefei Liu, Rui Zhao, Shuhui Cai

State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing 100083, China

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ABSTRACT

The North China Craton (NCC) is bounded by two Paleozoic accretionary arc terranes: the North Qinling terrane to the south and the Bainaimiao terrane to the north. The timing of arc accretion to the NCC and the architecture of the Bainaimiao arc remain unclear. During the building and accretion of the arcs along its margins, the NCC experienced a long sedimentary hiatus since the Ordovician, which ended with the deposition of bauxite-bearing sediments in the Late Carboniferous. In this paper we report the U–Pb and Hf isotopes of detrital zircons from the Late Carboniferous bauxite layer and use these data to constrain the tectonic evolution of the margin of the NCC. The detrital zircons yield a minimum U–Pb age of ca. 310 Ma and a prominent age peak at ca. 450 Ma. Zircon crystals with ages of ca. 330 Ma and ca. 1900 Ma are more common in the bauxite samples from the northern part of the NCC than in those from the central part. The εHf(t) values of the ca. 450 Ma detrital zircon crystals of the bauxite samples from the NCC are similar to those of the contemporaneous detrital zircon crystals from the North Qinling arc terrane to the south, but different from those of the contemporaneous detrital zircon crystals from the Bainaimiao arc terrane to the north. The ca. 450 Ma detrital zircon crystals in the ca. 310 Ma bauxite deposits are therefore interpreted to have been derived from the North Qinling arc terrane. The source of the ca. 330 Ma detrital zircon crystals of the bauxite deposits is interpreted to be the northern margin of the NCC, where intermediate-felsic plutons formed at ca. 330 Ma are common. The results from this study support the interpretation that the Paleozoic continental arc terranes and their concomitant back-arc basins were developed along the margins of the NCC before ca. 450 Ma, and the arc complexes were subsequently accreted to the craton in the Late Carboniferous. This was then followed by the formation of a walled continental basin within the NCC.

1. Introduction

The North China Craton (NCC) is bounded by the southernmost branch of the Central Asian Orogenic Belt (CAOB) to the north and by the Qinling orogenic belt to the south (Fig. 1a). Arc development and accretion occurred in these two orogenic belts in the Paleozoic. Despite detailed outcrop-based studies of the magmatic and tectonic evolution of these two belts (Xiao et al., 2003; Dong et al., 2011a), the timing of arc accretion to the NCC remains unclear, as does the architecture of the southernmost branch of the CAOB (Dong et al., 2011a; Zhang et al., 2013). This is partly due to the absence of sedimentary records from the Middle Ordovician to the Late Carboniferous within the NCC. Sedimentation in the NCC occurred until the deposition of a Late Carboniferous bauxite layer, which overlies the Ordovician karstified carbonates. A continental basin then developed within the NCC from the Permian to the Mesozoic, receiving a huge volume of sedimentary materials. The Late Carboniferous bauxite layer, which provides over 2.3 billion tons of ores, contains abundant detrital zircon crystals that are useful for the studies of sedimentary provenance and the tectonic evolution of the source regions.

The allochthonous bauxite layer overlying a karstified paleo-surface in the NCC is the karst-type deposit based on the classification of Bárdossy (1982). The geology, mineralogy, chemical compositions, and deposition pH–Eh conditions have been studied in detail (Wang et al., 2012a; Liu et al., 2013). The provenance of the bauxite ores has been investigated by many researchers using immobile elements such as Ga, Cr, Ni, Th, Zr, Hf, Nb, and Ta, following the methods of Mongelli (1997) and Mameli et al. (2007). Most researchers suggested that either the nearby Precambrian metamorphic rocks or the underlying Ordovician carbonates are the sources of the bauxite deposits in the NCC (e.g., He et al., 2007; Feng, 1992; Wang et al., 2012b). The results based on immobile elements are inconclusive, because multiple sources could have contributed materials at the same time, plus the inevitable element fractionation due to mineral separation during particle transportation by water. The karst-type bauxites commonly contain abundant detrital zircon crystals (Deng et al., 2010; Boni et al., 2012) that can be used for the studies of sedimentary provenance and the tectonic

* Corresponding author.
E-mail address: wqf@cugb.edu.cn (Q. Wang).

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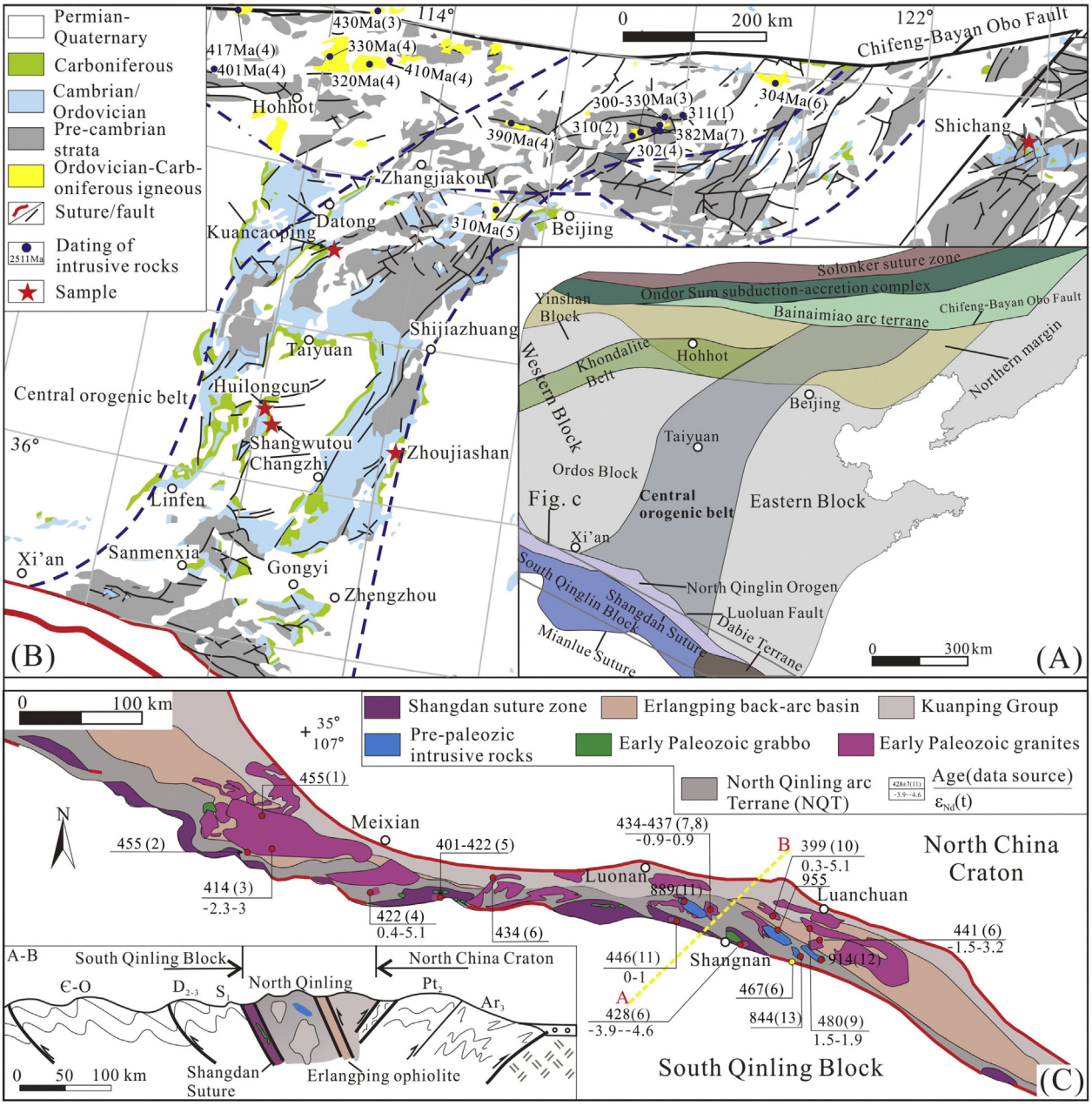

Fig. 1. Geological maps of the NCC (a and b) and the North Qinling orogenic belts (c), the NCC geological map is modified from Ma et al. (2002) and Dong et al. (2015). The zircon U–Pb age data shown in this map are from (1) S.H. Zhang et al. (2004); (2) Zhang et al. (2007a); (3) Zhang et al. (2007b); (4) Zhang et al. (2011); (5) Ma et al. (2013); (6) Zhang et al. (2006); (7) G.Z. Shi et al. (2013); (8) Teng et al. (2015). The geological map of the North Qingling orogenic belt is from Wang et al. (2009) and Dong et al. (2011a). The zircon U–Pb age data shown in the map are from (1) Chen et al. (2007); (2) Chen et al. (2008a); (3) Xu et al. (2008); (4) Chen et al. (2008b); (5) Chen et al. (2006); (6) Yan et al. (2007); (7) Lerch et al. (1995); (8) Lu et al. (2003b); (9) C.L. Zhang et al. (2004); (10) Wang et al. (2005); and (11) Li et al. (2000). The Ar–Ar age data shown in the map are from Mattauer et al. (1985) and Dong et al. (2011b). The marked locations are the sample sites of this study.

evolution of the source regions (e.g., Cawood et al., 2012; Wang et al., 2014). Based on the age distribution of detrital zircon crystals from the bauxite deposits in the NCC, Y. Wang et al. (2010) suggested that the mountain range on the southern or northern margin of the craton could have supplied the detrital zircon crystals. However, the exact provenance is not known because both regions contain abundant intermediate-felsic plutons with similar ages. This uncertainty may be resolved if the Hf isotopes of the detrital zircon crystals are also determined. In this paper, we report integrated U–Pb ages and Hf isotopes for the detrital zircon crystals from several bauxite deposits that occur in the central and northern parts of the NCC. We use these data to evaluate the provenance of the detrital zircon crystals and the tectonic evolution of the source regions.

2. Regional geology

2.1. North China Craton

The cratonization of the NCC was completed by the end of the Neoarchean through the amalgamation of several micro-blocks, as indicated by Neoarchean granulite facies metamorphism and granitic magmatism along the sutures (Zhao et al., 2001; Yang et al., in press).

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