Precambrian Research 301 (2017) 36–48

Contents lists available at ScienceDirect

Precambrian Research

journal homepage: www.elsevier.com/locate/precamres

SHRIMP zircon U–Pb dating and Hf isotope analyses of the Muniushan Monzogranite, Guocheng, Jiaobei Terrane, China: Implications for the tectonic evolution of the Jiao–Liao–Ji Belt, North China Craton

Shao-Bo Cheng[a], Zhen-Jiang Liu[a,*], Qing-Fei Wang[a], Bo Feng[b], Xing-Liang Wei[b], Bi-Zheng Liu[c], Lian-Yuan Qin[b], Bao-Ju Zhao[d], Peng Shui[a], Lei Xu[a], Jian-Ping Wang[a]

[a] School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China
[b] Shandong Yantai Xintai Gold Mining Industry, Yantai 265147, China
[c] Beijing Jinyou Geological Exploration, Beijing 100011, China
[d] No. 1 Institute of Geology and Mineral Resources of Shandong Province, Jinan 250014, China

ARTICLE INFO

Keywords:
Jiao–Liao–Ji Belt
Paleoproterozoic granitoids
SHRIMP zircon U–Pb dating
In situ Hf isotopes
Jiaodong
North China Craton

ABSTRACT

The Paleoproterozoic granitoid rocks in the Jiaobei Terrane, which lies in the southern part of the Jiao–Liao–Ji Belt (JLJB) in China, provide valuable information on the tectonic and evolutionary history of the North China Craton (NCC). SHRIMP U–Pb dating of zircons from the Muniushan Monzogranite in the Guocheng gold deposit area, as well as *in situ* Hf isotope analyses of the zircons, were used to constrain the ages of emplacement and metamorphism, and to understand the petrogenesis of the granite. The geochronological data show emplacement ages of ca. 2.1 Ga and metamorphic ages of ca. 1.85 Ga. The magmatic cores of the zircons have εHf(t) values of −0.51 to 4.00 (average 1.98) and depleted mantle two-stage model ages (T_{DM2}) of 2444–2703 Ma (average 2563 Ma). The rocks show the same trends of crustal evolution as ca. 2.5 Ga tonalite–trondhjemite–granodiorite (TTG) rocks in the Jiaobei Terrane, indicating that they were formed by the remelting of those TTG rocks. The Muniushan Monzogranite is part of a linear belt of ca. 2.2–2.0 Ga Paleoproterozoic granitoids within the JLJB. The granitoids are A-types, and are accompanied by coeval mafic intrusions and bimodal volcanic rocks, thus indicating widespread extension along the JLJB in the period 2.2–2.0 Ga. The ca. 1.85 Ga metamorphism was related to the collision of the Longgang and Nangrim blocks. The Paleoproterozoic evolution of the NCC constrains the crustal architecture and the source of Mesozoic granitoids in the Jiaobei–Sulu region. Inherited zircons of Paleoproterozoic age are widespread in the Mesozoic granitoids. In addition, Paleoproterozoic ages have been reported from lower crustal granulite xenoliths in the Sulu Orogen, and the southeastern margin of the NCC mirrors the evolution of the JLJB. It is probable, therefore, that NCC lower crust underlies the Sulu Orogen, and that the NCC was the main source for the Mesozoic granitoids in the Jiaobei–Sulu region. This view is consistent with the appearance of inherited zircons of Archean and Paleoproterozoic age on both sides of the orogen, normal $\delta^{18}O$ values of magmatic zircons, and Paleoproterozoic to Archean two-stage Hf model ages for the granitoids.

1. Introduction

The Paleoproterozoic marks an important period in the long geological history of the North China Craton (NCC), when the final amalgamation of the NCC occurred (Kusky et al., 2016; Lu et al., 2006; Wei et al., 2014; Zhai and Liu, 2003; Zhai and Santosh, 2011; Zhao et al., 2005). Besides outcrops of Paleoproterozoic rocks and the widespread Paleoproterozoic metamorphism of basement rocks, Paleoproterozoic signatures are also found as inherited zircons in Mesozoic granitoids and in lower-crustal granulite xenoliths brought up by volcanic rocks (Ma et al., 2013; Tang et al., 2014; Ying et al., 2010; Zhao et al., 2016a; Zheng et al., 2012). Thus, understanding the Paleoproterozoic evolution of the NCC will not only constrain the Precambrian evolution of the NCC, but also advance our understanding of some key issues regarding the Phanerozoic evolution of the region.

Paleoproterozoic assemblages in the NCC are restricted mainly to three major Paleoproterozoic mobile belts: the Khondalite Belt, the Trans-North China Orogen (TNCO), and the Jiao–Liao–Ji Belt (JLJB)

* Corresponding author at: School of Earth Sciences and Resources, China University of Geosciences, Beijing, No. 29, Xueyuan Road, Beijing 100083, China.
E-mail address: lzj@cugb.edu.cn (Z.-J. Liu).

http://dx.doi.org/10.1016/j.precamres.2017.09.002
Received 14 April 2017; Received in revised form 2 September 2017; Accepted 5 September 2017
Available online 06 September 2017
0301-9268/

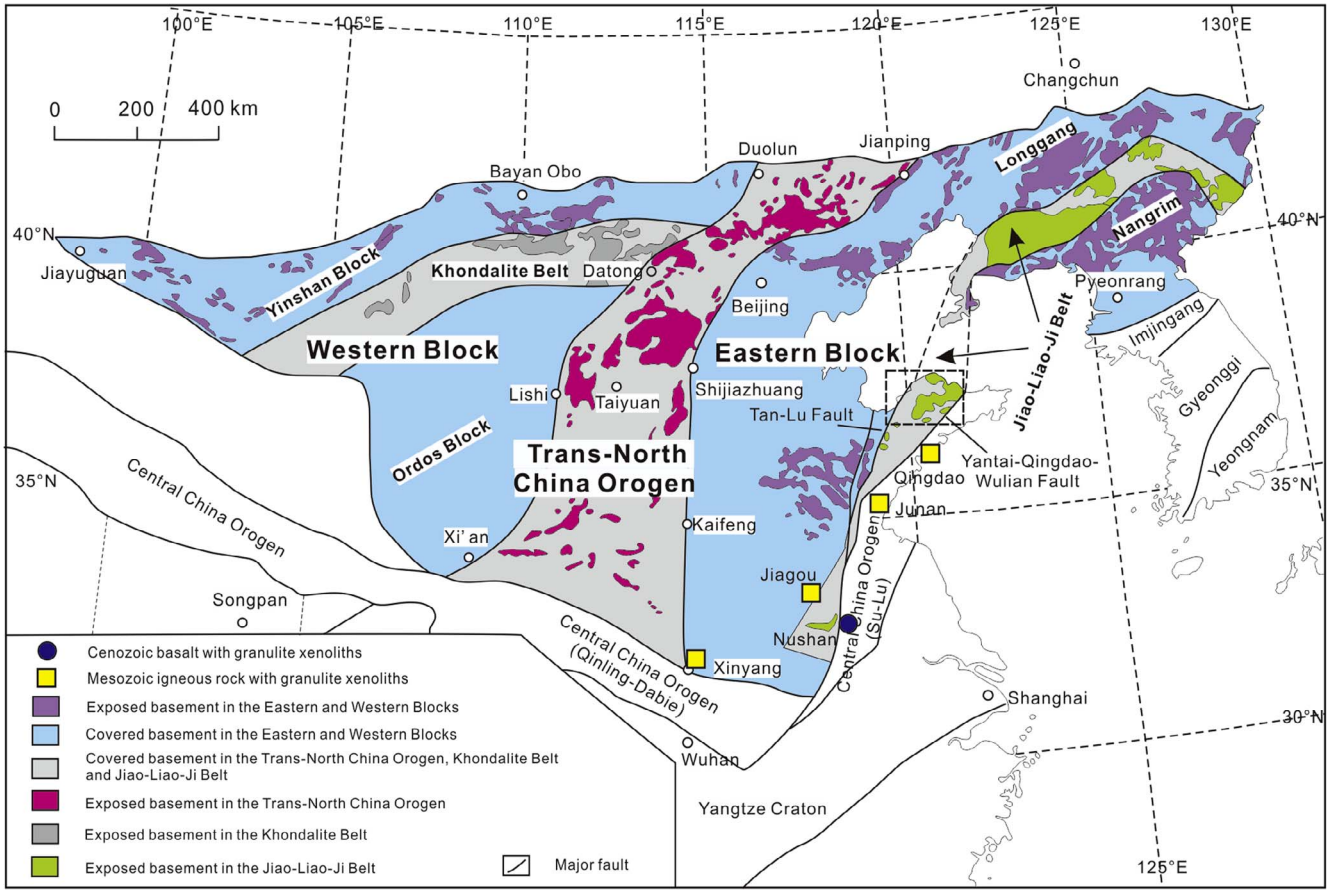

Fig. 1. Tectonic subdivision of the North China Craton (modified after Ping et al., 2015; Zhao et al., 2012). The rectangle indicates the location of the Jiaobei Terrane. Locations of rocks bearing granulite xenoliths along the southeastern margin of the North China Craton and the Sulu Orogen are also shown.

(Fig. 1) (Zhao and Zhai, 2013; Zhao et al., 2005). The JLJB is the mobile belt along which the northern and southern Longgang blocks amalgamated to form the coherent Eastern Block of the NCC (Li et al., 2012). Lithological investigations have shown that the belt consists mainly of metasedimentary rocks, volcanic successions, granitoids, and mafic intrusions. Further geochemical, geochronological, metamorphic, and structural investigations have revealed a complicated history of magmatism, tectonic deformation, multiple metamorphisms, crustal reworking, and growth of the JLJB (Dong et al., 2011; Li et al., 2005, 2012; Li and Zhao, 2007; Liu et al., 2014a,b, 2015a, 2013c, 2015c; Luo et al., 2004; Tam et al., 2011, 2012b; Wan et al., 2006; Zhao et al., 2015; Zou et al., 2017). A variety of geodynamic models have been proposed, including continental–arc–continent collision (Bai, 1993; Faure et al., 2004) and the opening and closing of an intra-continental rift (Li and Zhao, 2007; Li et al., 2005; Luo et al., 2004, 2008; Peng and Palmer, 1995; Zhang and Yang, 1988).

Granitoid rocks feature throughout all the stages of the Paleoproterozoic evolution of the region, and they are commonly metamorphosed, which means they can provide valuable information on the tectonic and evolutionary history of the JLJB. Numerous works have focused on the Paleoproterozoic granitoids in the northern segment of the JLJB, which are also known as the Liaoji Granitoids (Cai et al., 2002; Hao et al., 2004; Li and Zhao, 2007; Lu et al., 2004, 2005). Nevertheless, the Paleoproterozoic granitoids in the Jiaobei Terrane (which is the southern segment of the JLJB) have not been studied until very recently. Lan et al. (2015) reported alkali-feldspar and albite granites in the Changyi area, and Liu et al. (2011, 2014b) reported gneiss, syenogranite, and pegmatitic granite in Laiyang and Qixia, which they classified as pre-tectonic or post-tectonic, based on their zircon U–Pb ages and whether they were deformed. Analyses of the petrogenesis and tectonic implications of these rocks have improved our understanding of the evolutionary history of the JLJB. However, more work needs to be done, especially since more Paleoproterozoic granitoids await identification in the Jiaobei Terrane.

The Muniushan Monzogranite in the Guocheng area serves as a major host for the Guocheng gold deposit (Tan et al., 2012, 2015), and it was previously described as the Paleoproterozoic Jingshan Group or as a Mesozoic granite on former geological map of the area. We have now performed SHRIMP U–Pb dating and *in situ* Hf isotope analyses of zircons from the monzogranite to constrain the ages of its magmatism and metamorphism, and to understand its petrogenesis, all of which are critical to our understanding of the Paleoproterozoic evolution of the Jiaobei Terrane. Paleoproterozoic signatures are also found in inherited zircons from Mesozoic granitoids and in lower-crustal granulite xenoliths. All these data will be integrated to help us determine the crustal architecture and source of Mesozoic granitoids in the Jiaobei–Sulu region.

2. Geological setting

The NCC has a multi-stage evolutionary history of more than 3.8 Ga, which includes an important period of crustal growth in the Archean, the amalgamation of various continental blocks in the Paleoproterozoic, and destruction in the Mesozoic (Liu et al., 2013a; Wang et al., 2015b; Zhai and Liu, 2003; Zhai et al., 2011; Zhu et al., 2012). The process of amalgamation in the Paleoproterozoic involved a number of microcontinental blocks and is recorded by three major mobile belts of Paleoproterozoic age. The collision of the Yinshan and Ordos blocks along the Khondalite Belt formed the Western Block (Li et al., 2011b; Wang et al., 2011; Xia et al., 2006a,b, 2008, 2009; Yin et al., 2009, 2011), the