SHRIMP U–Pb Geochronology of Zircon in the North China Craton: Revealing Late Archean Tectonic Events in the Jining Area

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Objective

Early Precambrian rock is widely distributed in the khondalite series belt of the North China Craton (NCC), and previous studies have shown that metamorphic ages of ~2.5 Ga and ~1.95 Ga are widespread. The Neoarchean charnockite of the Yinshan Block has been a topic of great interest for understanding the Precambrian geology of the NCC (Zhao et al., 2005). Although there is a broad consensus that there were two stages of Late Neoarchean and Late Paleoproterozoic tectonic events at the northern margin of the NCC, there are still few reports of Archean research in the Jining area and ongoing controversy about whether the Jining area was involved in Archean tectonic events. SHRIMP zircon U–Pb dating of newly discovered charnockite and retrogressive biotite–hornblende gneisses together represent direct evidence for the superimposed reformation of two stages of late Neoarchean and Paleoproterozoic tectonic thermal events in this region.

Methods

Charnockite and biotite–hornblende gneiss samples were collected from near Jining Sanchakou, at the northern margin of the NCC (b44-1: E 112°56′48″, N 41°01′06″; b54-1: E 112°57′19″, N 41°00′53″; b40-1: E 112°35′26″, N 41°04′02″). Zircon U–Pb dating was carried out using the SHRIMP II instrument at the Beijing SHRIMP Center, Institute of Geology, Chinese Academy of Geological Sciences (Data in Appendix 1). Samples were collected from the eastern segment of the khondalite series belt, which is sandwiched between the Yinshan and Ordos Blocks in the Western Block, east of the Central Orogenetic Belt of the Jining area in the NCC. We aimed to study the petrogenesis and tectonic geological significance of the charnockite and retrograde metamorphic biotite–hornblende gneiss by means of petrogeochemistry and isotopic chronology.

Results

Based on the SiO₂ content, charnockite was divided into intermediate charnockite (SiO₂ content: 55.55–63.70 wt.%; composed of hypersthene (3%), diopside (2%), plagioclase (50%), microcline (25%), and quartz (15%)) and silicic charnockite (SiO₂ content: 69.99–71.79 wt.%; composed of hypersthene (3%), diopside (2%), plagioclase (35%), microcline (40%), and quartz (20%). The retrograde metamorphic biotite-hornblende gneiss was composed of plagioclase (35%), microcline (40%), quartz (15%), and biotite (5%). Zircon grains from these samples were 100–200 um in length and usually had core–mantle–rim structures. A portion of the core zircons were completely dissolved and replaced by mantle zircon (4.1C, 11.1C). A portion of the core and mantle zircons had textural and compositional features similar to both metamorphic and magmatic zircons; they also had homogenous or blurred oscillatory zoning, with a high U contents, but the Th/U ratios were 0.20–0.47; all of these characteristics may indicate an anatectic origin (Wan et al., 2009; Dong et al., 2009). Some gray mantle zircons and white–edged zircon had typical metamorphic zircon characteristics. The zircon U–Pb dating data can be classified into three groups. ①Core and mantle zircons of anatectic origin yielded 207Pb/206Pb weighted-mean ages of 2,469 ± 9 Ma (MSWD = 1.6, N = 6; Th/U = 0.33–0.51; Fig. 1c, 4.1C, 5.1C, 7.1C, 11.1C, 13.1C, 15.2C) and 2,474 ± 15 Ma (MSWD = 0.63, N = 2; Th/U = 0.20–0.47; Fig. 1a, 4.1M, 5.1M), and metamorphic recrystallized zircon yielded 207Pb/206Pb weighted ages of 2,492 ± 29 Ma (MSWD = 2.0, N = 4; Th/U = 0.31–0.37; Fig. 1c, 1.1C, 8.1C, 9.1C, 10.1C), which represent a stage of metamorphic anatectic events related to late Neoarchean tectonic thermal events. ② The gray mantle-rim zircons of metamorphic origin yielded 207Pb/206Pb weighted-mean ages of 1,921 ±
8 Ma (MSWD = 0.96, N = 3; Th/U = 0.01–0.07), 1.918 ± 9 Ma (MSWD = 2.0, N = 7; Th/U = 0.39–3.67), and 1.944 ± 30 Ma (MSWD = 2.0, N = 5, Th/U = 0.58–3.66), which were related to a stage of Paleoproterozoic tectonic thermal events. The metamorphic white-edged zircon was very narrow, and we only obtained $^{207}$Pb/$^{206}$Pb weighted-mean ages of 1.851 ± 12 Ma (Th/U = 0.15), which may be related to a ~1.85 Ga metamorphic event in the NCC. The Jining charnockite and biotite–hornblende gneiss are strongly depleted in LILEs (e.g., Cs), heat-producing elements (e.g., U and Th), and HFSEs (e.g. Nb, Ta, P, and Ti), and enriched in Sr. They also exhibit both positive and negative Eu anomalies.

Fig. 1. SHRIMP zircon U-Pb concordia diagram of intermediate Charnockite (a), silicic Charnockite (b), Biotite–Hornblende Gneiss (c) and Age histogram diagram (d).

Conclusions

We report our new discovery of ~2.5 Ga charnockite and biotite–hornblende gneiss from the Jining area of the North China Craton, and obtained metamorphism ages of 1.92–1.95 Ga. Based on comparison with previous studies, we confirmed that the Jining area shows superimposed reformation of two stages of late Neoarchean and Paleoproterozoic tectonic thermal events (Fig. 1d).

Acknowledgments

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Reference

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