Episodic growth of the Archean crust in the southern Zimbabwe Craton: Evidence from petrology, zircon U-Pb geochronology and Lu-Hf isotopes

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The Archean crust contains the record of events and processes involved in the early evolution of the earth because it is widely accepted that at least 50%–60% of the continental crust formed by the end of the Archean (Taylor and McLennan, 1995). The Zimbabwe Craton in southern Africa is a good example of an Archean crust. To the south of the Zimbabwe Craton is the Limpopo Complex, which is a high-grade metamorphic zone squeezed between the Zimbabwe Craton to the north and Kaapvaal Craton to the South. The Northern Marginal Zone (NMZ) of the Limpopo Complex is juxtaposed onto the low-grade gneisses of the Zimbabwe Craton. A systematic study of the Zimbabwe Craton and Limpopo Complex may provide important information about the formation and evolution of the continental crust during the early earth’s history. In this perspective, we studied petrology and zircon U-Pb geochronology in combination with Lu-Hf isotope data from the southernmost part of the Zimbabwe Craton and the adjacent NMZ with an aim to better understand the crustal growth during the Archean period in this region.

The Zimbabwe Craton is mainly composed of basement gneisses, three stages of greenstone belts, granites, and mafic-ultramafic layered intrusion of the Great Dyke (Wilson et al., 1995). The southernmost part of the Zimbabwe Craton is composed mainly of migmatitic tonalite–trondhjemite–granodiorite (TTG) gneisses and greenstone lithologies of metasedimentary and metavolcanic rocks, whereas NMZ is mainly composed of charnockitic and enderbitic rocks that are intercalated with migmatitic biotite-hornblende gneiss. Small amounts of pelitic, mafic to ultramafic gneiss and banded iron formation also occur in this area (Tsunogae et al., 1992; Ridley J., 1992).

Our zircon analysis of the migmatitic biotite gneiss from the NMZ yielded two discrete ages of 2.93 Ga and 2.63 Ga, which were inferred as the timings of protolith felsic magmatism and high-grade metamorphism, respectively, suggesting that the protolith of the basement rock was formed by Mesoarchean felsic magmatism. Most of the charnockites in the NMZ intruded into the Mesoarchean basement at 2.69 to 2.63 Ga, which implies regional Neoarchean felsic to intermediate magmatism. Several previous studies also reported similar Neoarchean magmatism in the NMZ at around 2.60 Ga. The charnockite magmatism was followed by high-grade (granulite-facies) metamorphism during 2.63 to 2.61 Ga as inferred from zircon U-Pb ages of biotite gneiss and mafic granulite from the NMZ. Although the heat source of such regional charnockite magmatism and subsequent granulite-facies metamorphism is not known, Brandt et al. (2018) argued that heat input through the intrusion of hot asthenospheric material might have caused the melting of the overlying crust of the NMZ. Razi Granite intruded into the North Limpopo Thrust Zone at 2.54 Ga. The infiltration of the Razi granite may have partly reset the age of surrounding charnockite in NMZ. Field evidence and petrographic study suggest that the granite was affected by the granulite-facies metamorphism and partial melting (Blenkinsop, 2011). The Zimbabwe Granite, which is a major unmetamorphosed granitoid intruded into the southernmost part of the Zimbabwe Craton, gave a Neoarchean magmatic age of 2.60 Ga that is slightly younger than the charnockite magmatism within the NMZ and consistent with the timing of peak metamorphism in the NMZ. It is interesting to note that the NMZ charnockite and the Razi Granite contain similar >2.9 Ga zircon xenocrysts, suggesting that both the charnockite and the Razi Granite were formed by partial melting of the Mesoarchean basement rock of the Zimbabwe Craton.

Lu-Hf isotopic analyses of zircons in all the orthogneiss and the granitoid samples indicate that the rocks were sourced from similar Paleo- to Mesoarchean (ca. 3.6-3.2 Ga) crustal component. Based on our new data, we infer that the southern part of the Zimbabwe Craton and the NMZ experienced several stages of felsic magmatism and high-grade metamorphism's during Paleoarchean to Neoarchean, possibly related to continuous high heat flow in this region from hot asthenosphere.

Keywords: Paleoarchean to Neoarchean, Zircon U-Pb geochronology, Zircon Lu-Hf isotope, Northern Marginal Zone of the Limpopo Complex, Zimbabwe Craton