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Zircon Hf-O isotopic evidence for generation and reworking of ancient crust in Swaziland

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The Earth's continental crust is distinct from the crust of other planets in our Solar System and has had a key role in the evolution of this planet. The broad compositional features of the continental crust are now well established using several approaches [1]. However, its formation, differentiation and evolution remain the topic of considerable debate. Here we report U-Pb ages and Hf and O isotopes for zircon grains in river sands and ancient intrusive rocks from the Ancient Gneiss Complex of Swaziland, the oldest components of the Kaapvaal craton, southern Africa, to constrain the formation, differentiation and evolution of the ancient continental crust.

Zircon grains from sands in the Komati and Usutu Rivers have U-Pb ages of 3.54 Ga to 489 Ma, with respective peaks at 3.54 Ga, 3.48-3.39 Ga, 3.26-3.02 Ga, 3.18-3.06 Ga, 3.00-2.93 Ga, 2.74-2.72 Ga, 1116-718 Ma, and 546-489 Ma. The old ages (>2.7 Ga) are consistent with published regional metamorphic and emplacement ages of intrusive rocks in the Barberton Greenstone Belt and the Ancient Gneiss Complex of Swaziland [2]. Zircon grains with young ages are possibly derived from the southern or eastern margins of the Kaapvaal craton. Combined with published ages, it is concluded that there were six episodes of Archean magmatism in Swaziland, i.e., 3.66-3.60 Ga, 3.56 Ga, 3.48-3.39 Ga, 3.27-3.20 Ga, 3.00-2.93 Ga, and 2.74-2.71 Ga. The four older episodes produced TTG rocks with minor high-K granitoids, whereas, the two younger episodes generated typical high-K granitoids. The oldest high-K granitoids (approximately 3.55 Ga) occur as clasts in a conglomerate in the Moodies Group of the Barberton Greenstone Belt [3]. Metamorphic zircon grains mainly have ages of 3.48-3.39 Ga and 3.27-3.20 Ga, consistent with strong TTG magmatic events [2].

The magmatic zircon grains have variable $\delta^{18}O$ and $\varepsilon_{Hf}(t)$ values. Zircons with ages older than 3.2 Ga have mantle-like $\delta^{18}O$ values and positive $\varepsilon_{Hf}(t)$ values, indicating that their host intrusive rocks were derived from the depleted mantle and/or juvenile continental sources, whereas, the young zircon grains have variable $\varepsilon_{Hf}(t)$ values from -5 to +5 and variable $\delta^{18}O$ values, suggesting that their host rocks were mainly derived from ancient continental crust with addition of depleted mantle-derived material. Metamorphic zircon grains have variable $\delta^{18}O$ values of +3 to +8 ‰, indicating low- to high-temperature metamorphism.

Collectively, all our U-Pb ages and isotopic features are consistent with the interpretation that the continental crust in Swaziland and the Barberton greenstone terrane was mainly generated before 3.2 Ga, but less than 3.9 Ga ago, the oldest Hf model age in Swaziland, and the cratonization time of the eastern Kaapvaal craton is about 3.1 Ga. The ancient crust has been reworked and differentiated since at least 3.66 Ga through magmatic events and formed the typical crustal structure as currently observed.

References:

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