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The U-Pb, Hf and O isotopic record of ancient detrital zircons in Zimbabwean sediments – formation, reworking and nature of early Archaean crust

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Hafnium and oxygen isotopic compositions measured in-situ on U-Pb dated zircon from different Archaean sedimentary successions belonging to the 2.9-2.8 Ga Belingwean/Bulawayan Groups and undated Sebakwian Group are presented to better define the crustal evolution of the Zimbabwe Craton prior to 3.0 Ga. Textural and compositional criteria were employed to minimize effects arising from Pb loss, metamorphic overprinting and interaction with low temperature fluids. $^{207}Pb/^{206}Pb$ age spectra (concordance > 90%) reveal prominent peaks at 3.8, 3.6, 3.5, and 3.35 Ga, corresponding to documented geological events both globally and within the Zimbabwe craton. O isotope compositions of $\sim$ 4 - 10 ‰point to both derivation from magmas in equilibrium with mantle and the assimilation of supracrustal material or interaction with metamorphic fluids. In εHf-time space, 3.8-3.6 Ga grains define an array consistent with derivation from a mafic to intermediate source reservoir (Lu/Hf ~0.015) that separated from chondritic mantle at $\sim$ 3.9 Ga. Crustal domains formed after 3.6 Ga depict a more complex evolution, involving contribution from juvenile mantle sources and reworking of pre-existing crust. Importantly, initial Hf isotopic compositions document a protracted history of remelting, without evidence for significant mantle depletion prior to 3.35 Ga. This suggests that production of earliest crust in the Zimbabwe Craton did not cause complementary enriched and depleted reservoirs, possibly because heterogeneous mantle was effectively remixed by rapid convection due to higher temperatures in the early Archaean or the volume of crust was too small in volume to influence the isotopic mantle evolution. Similar Hf-O-time relationships observed in southern West Greenland were used as a basis to propose a transition in geodynamics 3.2 Ga ago. The absence of detrital zircons with crystallization ages > 3.8 Ga, along with a simple εHf-time array consistent with reworking of a mafic protolith, suggests the absence of subduction and crustal accretion prior to 3.8 Ga. A progressive enrichment in ^{18}O in the 3.8 – 3.6 Ga zircons with time, coupled with decreasing εHf, requires a closed-system. This was accomplished by remelting of mafic crust that was progressively altered by interaction with water at low temperatures. With time, progressive foundering or burial of this altered crust caused increasing contribution of ^{18}O-enriched crust in magmas. In contrast, vertical arrays in εHf-time space document concomitant juvenile input and crustal reworking, suggesting that a modern-style plate tectonic regime was established after $\sim$ 3.6-3.3 Ga. Residence times for zircon with mantle-like and non-mantle-like $\delta^{18}O$ range from 0 - 100 myr and 100 – 450 myr indicating that early crust was able to escape reworking for extended periods of time.