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Testing the reliability of information extracted from ancient zircon

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Studies combining zircon U-Pb chronology, trace element distribution as well as O and Hf isotope systematics are a powerful way to gain understanding of the processes shaping Earth's evolution, especially in detrital populations where constraints from the original host are missing. Such studies of the Hadean detrital zircon population abundant in sedimentary rocks in Western Australia have involved analysis of an unusually large number of individual grains, but also highlighted potential problems with the approach, only apparent when multiple analyses are obtained from individual grains. A common feature of the Hadean as well as many early Archaean zircon populations is their apparent inhomogeneity, which reduces confidence in conclusions based on studies combining chemistry and isotopic characteristics of zircon. In order to test the reliability of information extracted from early Earth zircon, we report results from one of the first in-depth multi-method study of zircon from a relatively simple early Archean magmatic rock, used as an analogue to ancient detrital zircon. The approach involves making multiple SIMS analyses in individual grains in order to be comparable to the most advanced studies of detrital zircon populations.

The investigated sample is a relatively undeformed, non-migmatitic ca. 3.8 Ga tonalite collected a few kms south of the Isua Greenstone Belt, southwest Greenland. Extracted zircon grains can be combined into three different groups based on the behavior of their U-Pb systems: (i) grains that show internally consistent and concordant ages and define an average age of 3805±15 Ma, taken to be the age of the rock, (ii) grains that are distributed close to the concordia line, but with significant variability between multiple analyses, suggesting an ancient Pb loss and (iii) grains that have multiple analyses distributed along a discordia pointing towards a zero intercept, indicating geologically recent Pb-loss. This overall behavior has important implications for the studies of detrital populations, suggesting that even zircon from a supposedly single population can form a complex age distribution pattern. Notably, the age groups are also very similar to those identified at this time interval in the zircon population from Jack Hills in Western Australia. Interestingly [U+F064]18O in zircon from the Greenland tonalite sample is very consistent at the mantle value and independent of the behavior of the U-Pb system, suggesting general stability of even metamict zircon as related to the O isotope exchange. At least it indicates that if this exchange takes place as it appears to be the case for the Hadean zircon, factors other than just the radiation damage have to play a role in the zircon modification.