The Importance of Imaging and Correlated In Situ Analyses: Trace Elements in >4 Ga Detrital Zircons

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The origins of >3900 Ma detrital zircons from Western Australia are controversial, and extreme interpretations have been published based on data from incompletely documented grains. These are complex crystals with multiple domains; some preserve magmatic chemistry, some are clearly altered, whilst others are more difficult to evaluate. Here, grain domains previously characterized by U/Pb age, $\delta^{18}O$, and cathodoluminescence (CL) were specifically targeted for trace element analysis by ion microprobe to evaluate if they preserve magmatic chemistry.

Domains within single zircons are classified into two types based on REE chemistry: Type 1 is the largest group (occurring in 37 of 42 grains), preserving evolved REE compositions typical of zircons from crustal igneous rocks. Zircon domains with Type 1 characteristics display a wide range of CL zoning patterns (e.g. oscillatory, sector), yield nearly concordant U/Pb ages from 4400-3900 Ma, and preserve a narrow range of $\delta^{18}O$ values from 5.3 to 7.3‰.

Type 2 domains are found in 6 grains that yield unusually enriched light-REE compositions, here defined as having a combination of chondrite normalized values of La_N >1 and Pr_N >10. Type 2 domains occur in areas with suspected alteration (e.g. U/Pb discordance, high Th/U ratios, or that have other irregularities (e.g. cracks, disturbed CL zoning), and are not interpreted as representative of magmatic zircon chemistry. The alteration processes that affected these grains do not necessarily require infiltration by hydrothermal fluids, and may have been enhanced by radiation damage or metamorphism.

The presence of altered domains does not indicate that an entire grain is altered, but demonstrates the importance of careful imaging combined with correlated *in situ* analyses. The REE data reported here support previous interpretations that the majority of >3900 Ma zircons from the Jack Hills are igneous and originated in felsic melts, consistent with the existence of continental crust very early in Earth's history. However, none of the documented samples in our dataset support more extreme conclusions, such as the presence of S-type granites and plate tectonics at 4.4 to 4.5 Ga.

References

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