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Resolving oxygen isotopic disturbance in zircon: A case study from the low $\delta^{18}O$ Scourie dikes, NW Scotland

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Abstract

In this paper, we describe an in situ non-destructive technique to identify areas within zircon crystals that have experienced fluid exchange. We show that Raman spectroscopy combined with electron microprobe trace-element analysis can be used to pinpoint areas in altered, complexly zoned, and metamict zircon that record the original magmatic compositions. These techniques are developed on a suite of Paleoproterozoic zircon crystals from the Scourie dike swarm in the Archean gneiss terrane of NW Scotland that are known to be anomalously low in $\delta^{18}O$.

We show that zircons from the Scourie dikes record extremely low-$\delta^{18}O$ isotopic compositions down to approximately –3‰, which reflect their magmatic values. Zircon populations from the dikes have a range in $\delta^{18}O$ from low values (<0‰) up to ~5‰ with no obvious relationship between oxygen isotopic composition and cathodoluminescence. Raman spectra from the zircons show evidence for fluid interaction in some areas of the grains because of partial recrystallization and atypical radiation damage properties. Electron microprobe analysis in the same areas documents high (>1000 ppm) U concentrations and high (>1000 ppm) abundances of non-formula Ca. When the combined Raman and electron microprobe data are used to filter the oxygen isotopic data, the fluid altered areas of the grains show consistently higher $\delta^{18}O$ values than the areas without evidence for fluid alteration. The low-$\delta^{18}O$ values therefore reflect the original magmatic composition of the grains and indicate that the Scourie dike magmas were low in ^{18}O. We suggest that these non-destructive techniques should be used prior to SIMS analysis of complex zircons to target the least disturbed areas of the grains.

Keywords: Zircon, metamictization, Raman, low ^{18}O, hydrothermal, alteration, Scourie