Slow oxygen diffusion in zircon

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Zircon is commonly regarded to preserve a geochemical record of its formation conditions because of chemical robustness and slow cation diffusion rates. However, oxygen diffusion experiments at P_{H2O}= 0.07 to 10 kbar suggest relatively rapid diffusion and a low closure temperature of ~550˚C for typical 100 µm diameter zircons and slow cooling (1-5˚C/Myr). Dry diffusion is significantly slower [Watson & Cherniak 1997 *EPSL*].

Zircons with relict igneous cores and igneous or metamorphic overgrowths were imaged by cathodo-luminescence and analyzed for oxygen isotope ratio by CAMECA 1280 ion microprobe (spot to spot precision 0.4‰, 2 SD). Core and rim $\delta^{18}O$ differ by 5 to 11‰ (VSMOW) for igneous cores and metamorphic/anatectic overgrowths. A series of analyses along core-rim interfaces delineate sharp $\delta^{18}O$ transitions in all zircons studied. The largest differences between adjacent spots are >8‰ over <10µm indicating that any diffusion profile is so sharp that it cannot be resolved with the 10 µm diameter spot.

The figure shows a zircon from a melanosome in the Adirondack Mts with an overgrowth that crystallized at 1174 Ma (Heumann et al., in review) during amphibolite facies metamorphism and anatexis (~675°C, 6-7kbar) followed by slow cooling. Other zircons were studied from diverse lithologies (metapelite, quartzite, altered granite, leucosome, melanosome) and metamorphic conditions (amphibolite, granulite, eclogite, migmatite). Analyses are mixtures within 5µm of the core-overgrowth boundary due to the 10µm spot diameter. Thus, exchange across the boundary (fig.) is not resolved. None of our measured profiles document faster oxygen diffusion in naturally occurring non-metamict zircons, even for cores preserved through two granulite facies metamorphisms ± anatexis. These data support the proposal (Peck et al. 2003 *Am. Min.*) that oxygen diffusion in zircon is much slower than experimentally derived values for hydrous conditions. These profiles from wet and dry metamorphic rocks support a closure T above 800˚C even for slow cooling.