Deciphering complex zircon growth and recrystallization histories in an anatectic granulite domain using LASS-ICP-MS depth profiling

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Zircon is the most widely used geochronometer in high grade metamorphic rocks, capable of maintaining closed isotopic and chemical systems through long durations at high temperature and multiple orogenic cycles. However, with changing environmental conditions and episodes of bulk rock deformation, metamorphic zircon may experience multiple phases of growth, dissolution, and recrystallization, resulting in complex internal isotopic and chemical zoning. Thus, a wealth of information on the timing, conditions, and reaction history of a particular rock volume may be stored within individual zircon crystals.

This study investigates the isotopic and chemical varaibility of zircon extracted from granitic leucosomes within boudinaged granulite layers, and associated cross cutting pegmatite, from the Parry Sound domain, Grenville Province, Ontario, Canada. Separated zircon crystals were analyzed by laser ablation depth profiling and simultaneous measurement of U and Pb isotopes and a number of important trace elements on adjacent single collector ICP-MS. Large (50 μm) spot sizes enabled laser sampling down to 30 μm, traversing multiple zones from the marginal metamorphic overgrowths to inherited cores near the center of the crystals. Time resolved evaluation of the measured signals enabled detection of variation in each of the analytes with depth, and correlation with zoning patterns observed in CL.

In most of the crystals, distinct $^{207}Pb/^{206}Pb$ age domains corellate with established protolith or metamorphic ages, and are separated by a transitional zone defined by monotonic changes in U-Pb isotopic composition. Transition zones are typically ~5 to 10 μm thick in leucosome samples and ~15-20 μm thick in the pegmatite sample, where they commonly correlate with dark (CL) bands and a distinct spike in U (and in some cases Ti and REE). REE typically covary across the zones, with few local Ce spikes not shown in the other REE. Hf shows little corellation with REE, Ti, or U, but varies inversely with $^{207}Pb/^{206}Pb$ age and shows similar gradational transition zones. Ongoing works aims to understand these charateristics in terms of zircon crystal-chemical behavior in evolving metamorphic environments, enabling more robust interpretation of the relationships between U-Pb ages and trace element concentrations.