

Ablating for Critical Minerals: In-situ Lu-Hf and Rb-Sr geochronology reveals complex histories of ore deposit formation and modification.

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Ore deposits are characterized by extreme enrichments of economic (critical) elements relative to crustal abundances, and the processes that form these deposits are often complex with multiple mineralization and alteration events. The ability to provide an absolute date on mineralization and paragenetic assemblages is important for not only deposit characterization, but also for exploration of new deposits. However, many ore deposits contain mineral assemblages that are not suitable for traditional geochronology (e.g., zircon U-Pb) so that it is difficult to obtain absolute ages on mineralization and certain styles of alteration.

New advances in laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) have allowed for the in-situ dating of a variety of minerals and decay systems beyond traditional geochronology methods. The development of tandem mass spectrometry (ICP-MS/MS) where an ICP-MS has two quadrupole mass filters with a collision-reaction cell in between has been an important new tool in geochronology. In ICP-MS/MS a reactive gas (NH₃, CH₄, etc.) is added to the collision-reaction cell that allows for the chemical separation of parent from daughter isotopes, with the same nominal mass by reacting one element to a different mass. This has allowed for in-situ geochronology of beta decay systems such as Rb-Sr, Lu-Hf, Re-Os and La-Ba, which opens the door to many non-traditional mineral geochronometers.

This presentation will utilize LA-ICP-MS/MS data to better understand the formation, timing and alteration histories of three different critical mineral deposits: The Mountain Pass Carbonatite, California, USA; the Mount Weld carbonatite in Western Australia; and the Strange Lake peralkaline complex in Canada. In each deposit we show a complex history of initial mineral crystallization/precipitation and subsequent modification occurs over significant geological time. Results suggest that later fluid events may leave imprints on these critical mineral deposits and this can only be constrained via in-situ analysis of these non-traditional geochronometers.