
**An investigation of chemical mobility and variability
within a metamict zircon from the Georgeville
Granite, Nova Scotia, using ToF-SIMS**

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Zircon, a mineral known for its chemical durability, is susceptible to chemical change after structural damage caused

by alpha-decay of U and Th. A metamict zircon from the Georgeville Granite, Nova Scotia, was analyzed by Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) to determine trace element variability between altered regions within a single crystal. Quantitative electron microprobe analysis and textural characteristics revealed in backscatter electron images were used to identify four distinct domains, herein designated A, B, C and D. These domains were separately analyzed using an ION-TOF (GmbH) ToF-SIMS IV instrument housed at Surface Science Western, London, Ontario. The ToF-SIMS technique was used because it can: 1) detect trace elements in the ppb level, 2) analyze a small spot size ($<1 \mu\text{m}$), and 3) measure a wide range of elements at one time. The main drawback of the ToF-SIMS technique is that it is difficult to quantify the results without a proper standard. However, it is ideal for examining micrometer scale trace element variations within a single zircon crystal such as those in the Georgeville Granite. The analyses indicate that the relative concentrations of most of the trace elements follow the general trend $A > B > D$. However, Li and K were found to be enriched in domain B and D. Domain C, which has a distinct trace element signature, represents small Th-rich inclusions within domain B. The major and trace element data for domains A, B and C indicate that the magmatic zircon was enriched in high field strength elements (HFSE) such as Ti, Ta, and most REEs. Alteration of this trace element-enriched zircon by hydrothermal fluids resulted in the partial dissolution of domain A and the subsequent precipitation of a trace element depleted zircon at lower temperatures (domains B and D). Some of the trace elements excluded from the reprecipitated zircon were incorporated into Th-silicate inclusions (domain C) that formed within pore spaces in domain B. The variation in trace element content between domains reflects the different conditions of zircon formation and the relative compatibilities of trace elements at these conditions. The observed alteration and chemical mobility of the trace elements within this zircon crystal is especially relevant to durability studies of various wasteforms which are designed to safely store radioactive waste such as weapons grade plutonium.