High Spatial Resolution *in situ* LA-ICPMS U-Pb Geochronology of Titanite and Apatite from the Coles Hill Uranium Deposit, Virginia, USA

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Coles Hill, the largest unmined uranium deposit in the United States, is hosted in hydrothermally altered quartzo-feldspathic augen gneisses and amphibolites of Ordovician-Silurian Martinsville igneous complex. Uranium mineralization is spatially associated with sodium metasomatized rocks. To better understand the genesis of the deposit, we conducted high spatial resolution (20-50 µm) *in situ* LA-ICPMS U-Pb analyses of titanite, Ti-oxide, and apatite in polished thin sections of unaltered host rocks and U ores. This work is challenging due to the equivocal mineral paragenesis, complex alteration history of these rocks, prevasive intergrowth, and small grain sizes of U ore and paragenetically related minerals.

The raw data collected using 193 nm LA-SC-ICPMS are reduced using Iolite™ software, normalized to NIST 610 glass as a primary non-matrix-matched standard and then corrected to titanite, rutile, and apatite matrix-matched U-Pb dating reference materials. Apatite is the primary dating target to determine the age of closely accociated mineralization, but the lack of a well-characterized high-U apatite standard was an additional hurdle.

Three distinct events were identified at Coles Hill: (i) crystallization of the host rock at ~450 Ma that formed primary euhedral titanite, in agreement with previous zircon dates from the Martinsville igneous complex, (ii) a regional metamorphic event at ~320 Ma that formed anhedral titanite and is coincident with previously dated movement of the Brookneal shear zone and, (iii) the youngest (200-250 Ma) event(s) that formed titanite alteration products (TiO_2) and high-U apatite closely associated with U mineralization.

The high-U apatite (up to ~1.5% U) has unusual Pb isotopic compositions with very low $^{207}Pb/^{206}Pb$ <0.02. Its U-Pb isotope data plot below the Tera-Wasserburg Concordia curve and form linear trends with near zero Y-axis intercepts — this suggests the presence of excess ^{206}Pb unsupported by *in situ* ^{238}U decay and presumably derived from ^{226}Ra and ^{222}Rn. These data indicate that apatite matrix can retain high concentrations of uranium and its short-lived decay products for hundreds of millions of years and makes it a promising waste form for long-term radionuclide isolation.