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Multistage, magmatic and hydrothermal evolution of the Debert Lake Rare Earth Element Prospect (REE), Nova Scotia, Canada

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The Debert Lake, Nova Scotia Canada Rare Earth Element (REE) prospect shows high, potentially economic rare metal concentrations but knowledge of the formative processes and timing for the deposit are lacking. This study provides a genetic model based on whole-rock and individual mineral geochemistry together with U-Pb radiometric dates from zircon and monazite.

The prospect is hosted by the Hart Lake-Byers Lake (HLBL) granitic member of the Wentworth Plutonic complex in the Cobequid Highlands. The complex contains both the HLBL granites and gabbroic rocks which have associated volcanic equivalents. Samples of alteration zones have up to 1.2 wt.% REE_2O_3, 3.4 wt.% ZrO_2, and 0.4 wt.% Nb_2O_5. These concentrations are comparable to the well-known Strange Lake (Labrador-Quebec) and Thor Lake (N.W.T.) REE deposits.

The host HLBL granites are anorogenic and dominated by feldspar, quartz and interstitial arfvedsonite. In mineralized zone, the host granite contains Nb-oxide (pyrochlore and fergusonite) phases, chevkinite, zircon, thorite, monazite and titanite. This REE assemblage shows intergranular to interstitial texture in mineralized granite. Zircons of the assemblage are euhedral that exhibit “spongy” textures with abundant, micrometer-sized Nb- and Th-rich mineral inclusions. Element distribution maps of zircon grains reveal distinct domains apparently related to Y, Th and Zr mobilization by metasomatizing fluids enriched in these elements. U-Pb dating of those zircons yields an age of ~361 Ma, approximately coeval with igneous monazite crystallization, dated at ca. 358 Ma. These findings document an early, magmatic REE mineralization event. One subsequent pulse of post-magmatic hydrothermal alteration associated with Zr-F-rich fluid complexes produced titanite, ferriallanite, pyrochlore, fergusonite and thorite. This hydrothermal REE assemblage also contains two, habit and form-distinct zircon populations with relatively low Th/U and HREE/LREE. These zircons yielded U-Pb ages that cluster between 310 and 320 Ma. Taken together, the variations in mineralogy, mineral chemistry, textures and radiometric dates outline a protracted, 45 million-year, multistage evolution for the deposit.