Petrology, geochemistry, and geochronology of the Tofty Ridge carbonatite: insights into petrogenesis

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The Tofty Ridge carbonatite of Interior Alaska preserves a polyphase mineralization history of late-stage magmatic niobium mineralization and later hydrothermal alteration. We present the results of petrography and whole rock x-ray diffraction analysis to determine carbonatite mineralogy, electron probe microanalysis to characterize niobium and REE-bearing mineral phases, and laser ablation split stream inductively coupled plasma mass spectrometry (LASS-ICP-MS) to determine U-Pb ages of carbonatite emplacement and Nb-REE mineralization.

Niobium enrichment occurs in magnetite- and apatite-rich dolomitic carbonatite sills. Rutile and ilmenite with Nb-enriched cores and depleted rims are disseminated through the carbonatite. Monazite, although limited in extent and modal abundance, is disseminated through the carbonatite in breccias, and as a secondary product after apatite dissolution. In-situ LASS-ICP-MS analysis of zircon grains yield a $^{206}Pb/^{238}U$ weighted mean age of 215.4 ± 2.4 Ma, interpreted to reflect crystallization of zircon from the carbonatite magma. Monazite petrochronology yields a $^{208}Pb/^{232}Th$ weighted mean age of 118.1 ± 1.1 Ma, interpreted to reflect secondary hydrothermal alteration. REE-bearing monazite was thus post-magmatic, formed or remobilized in a regional hydrothermal event. Rutile and ilmenite cores, meanwhile, show partial replacement by rims of a Nb-poor TiO_2 phase suggestive of an alteration event, but relict Nb-rich cores are interpreted to have crystallized directly from the carbonatite melt.