REE Mobility and Fluid Evolution at the Magmatic-Hydrothermal Transition of the Lemitar Carbonatite, NM

Eric Ruggles[1], Nicole C. Hurtig[1], Alexander P. Gyis[1,2], and Virginia McLemore[1,2]

[1]Dept. of Earth and Environmental Sciences, New Mexico Tech, Socorro, NM, 87801
[2]New Mexico Bureau of Geology and Mineral Resources, New Mexico Tech, Socorro, NM, 87801

The Lemitar Carbonatite, located in the Lemitar Mountains, NM, comprises 516.7±0.7 Ma old dikes intruded into Proterozoic mafic rocks [1,2]. This area comprises of more than one hundred surface exposures of carbonatite dikes with grades of up to 1.1% total rare earth element (REE) concentrations that show variable degrees of hydrothermal overprinting. Hydrothermal processes have been shown to be critical for REE mobilization and enrichment to economic levels [3]. This study aims to determine a mineral paragenesis and study fluid inclusions to highlight REE mobility and enrichment at the magmatic-hydrothermal transition in the Lemitar Carbonatite.

Magmatic minerals comprise of calcite, dolomite, phlogopite, magnetite, and apatite [1] overprinted by hydrothermal veins comprising of calcite, fluorite, and quartz. Alteration surrounding carbonatites includes potassic fenitization, hematization, F-Ca-metasomatism, chloritization, and silicification [4]. Cathodoluminescence imaging shows three distinct calcite generations of which calcite-1 is early and likely magmatic, calcite-2 is the early hydrothermal vein calcite and calcite-3 is the latest hydrothermal calcite generation. Apatite occurs in the fine-grained carbonate matrix, exhibits dissolution textures and is cross-cut by calcite-3. Calcite-2 occurs as euhedral crystals growing on hydrothermal vein walls overgrown and crosscut by calcite-3 and subsequently by quartz and fluorite. Four fluid inclusion types have been observed including: type-1 vapor-poor (5-15 vol% vapor) and type-2 vapor-rich (>30 vol% vapor) liquid-vapor inclusions, type-3 vapor-poor (5-15 vol% vapor) and type-4 vapor-rich (>30 vol% vapor) multiphase inclusions. Apatite displays inclusion types 1, 2, and 4, as well as melt inclusions. Type-1 and 3 inclusions occur in calcite-1, type-1, 2, and 3 inclusions occur in calcite-2, and type-2 and 3 inclusions occur in calcite-3, type 1 and 3 inclusions occur in quartz, and fluorite exclusively exhibits type-1 inclusions. Microthermometric data of fluorite-hosted type-1 inclusions show ice melting temperatures at -1.2 ± 0.1°C, and calcite-3 type-1 inclusions yielding -2.5 ± 0.08°C. Apatite-hosted type-2 and 4 inclusions show melting temperatures from -5.8 ± 0.2°C to -8.6 ± 0.15°C. Salinities are 2.07 wt% NaCl equivalent in type-1 fluorite-hosted inclusions, 4.18 wt% in type-1 calcite-3 hosted inclusions and 8.95 to 12.4 wt.% in apatite-hosted type-2 and 4, respectively. Preliminary data indicate a decrease in salinity and homogenization temperatures for fluid inclusions between apatite and fluorite from early to late in the paragenetic sequence.

[1] McLemore, 1987, The Journal of Geology, Issue 2, pg. 255-270.
[2] Haft et al., 2022, New Mexico Geological Society, 72nd Annual Fall Field Conference, pg. 365-373.
[3] Perry, E.P., Gysi, A.P., 2018. Rare Earth Elements in Mineral Deposits: Speciation in Hydrothermal Fluids and Partitioning in Calcite. Geofluids 2018, 1–19.

[4] Perry, E.P., 2019. Rare earth element signatures in hydrothermal calcite: insights from numerical modelling, experimental geochemistry, and mineral deposits in New Mexico. PhD. Thesis, 125.