

Ree-enrichment in Alkaline Ultramafic Cumulates: New Insights on the Carbonatite-ultramafic Rock Paradox From the Riviere Noire Clinopyroxenite, Grenville Province, Québec

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The Rivière Noire Intrusive Suite (RNIS) crops out in the Central-Western Grenville Province (Québec), and its emplacement time (~1130 Ma) predates the Grenvillian orogeny (1090–980 Ma). The RNIS is an alkaline complex formed by high Ba-Sr ultrapotassic rocks, consisting of titanite-apatite-allanite-bearing clinopyroxenite, with REE concentrations up to 0.3 wt.%. Local presence of carbonate-amphibole-rich pockets is interpreted as a result of the crystallisation of a late carbonatitic melt. These cumulates are crosscut by syenite dykes and pegmatitic-aplitic syenite dykes.

Diopside grains from the clinopyroxenitic cumulates are rich in primary complex inclusions formed by a fluid phase (20-80 vol.%) and solid phases. Microthermometry, Raman spectroscopy, and LA-ICP-MS were performed on these inclusions. The fluid phase appeared to be intermediate salinity (< 18 wt.% NaClEq) K-Na-Cl-H₂O-bearing fluids, while Raman spectroscopy indicates that the daughter phases are dominated by hydrated carbonates and titanites. The LA-ICP-MS analyses of those complex inclusions reveal strong enrichment in K, Ti, Ca, Sr, Ba, S, Cl, and Ti with low concentrations of Si, Mg and Fe. These results infer that the diopside crystals have crystallized from a Si-poor CO₂-LILE-sulphate-rich melt. In addition, diopside, titanite, apatite, and allanite phases have an unusual sinusoidal REE pattern marked by La and Ce depletion compared to Pr and Nd, and by Yb and Lu enrichment. This is characteristic of crystallisation of those minerals by carbonatite metasomatism.

Carbonatite metasomatism is a proposed model in which carbonatitic melt acts as agent of metasomatism, interacting with silicic host lithologies to form “antiskarn” rocks dominated by diopside, apatite, and titanite. This model explains the minerals sinusoidal REE pattern and the primary diopside-hosted complex inclusions. Nevertheless, the euhedral aspect of diopside grains, their Mg-Fe compositional core-rim zoning, the lack of aegirine compositions and the absence of any evidence of metasomatic reactions with the host rock challenge this model.