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High Pressure Experimental Investigations of the Crustal Evolution of Carbonatites

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Carbonatite systems are complex magmatic and hydrothermal systems emplaced in the Earth's crust. They are known from continental settings, in particular cratonic marginal zones and rifts, but are rare in oceanic settings. Their defining rock-type is carbonatite rock, a plutonic cumulate rock consisting mainly of carbonate minerals such as calcite, dolomite, siderite and ankerite. Accessory phases include phosphates, oxides, fluorides, silicates, sulfides and sulfates among others.

Carbonatites are major hosts of rare earth elements (REEs) and Nb which are essential for the transition to net zero energy production and an enormous range of other technological applications. Abundant and cost-effective supply is crucial but threatened by geopolitical factors, hence these commodities are designated as critical metals.

Mechanisms causing enrichment of REE and Nb in carbonatite systems remain poorly understood. I will report on recent high-pressure experimental investigations aimed at partially addressing this by experimental simulation of the crystallisation of parental carbonatite magma under crustal conditions, and by unravelling key controls on the solubilities of monazite ($REEPO_4$ - a key REE ore mineral; [1]) and pyrochlore [$(Na,Ca)_2Nb_2O_6F$ - the main ore mineral of Nb] in carbonatite magmas.

Using piston-cylinder apparatuses, we isobarically crystallised a model parental alkali-bearing calcio-carbonatite, derived experimentally from immiscibility with a conjugate nephelinite melt [2] at crustal pressure and temperatures at and below the liquidus, to better understand the magmatic evolution of these systems as they cool in the crust. We separately ran synthetic mixtures of a natural monazite and a stoichiometric pyrochlore compositions with sodic dolomitic to calcic carbonate melt to systematically quantify the effects on monazite and pyrochlore solubility of temperature, melt SiO_2 and F^- abundances and varying Ca#.

Our experimental results are a step towards better understanding the complexities of evolutionary processes of carbonatite magmas in the crust, and how these may contribute to critical mineral enrichment in some cases.

References

[1] Ray, S., Yaxley, G.M., Miller, L.A., Berry, A.J., 2025. Geochim. Cosmochim. Acta, 393: 1-17.

[2] Weidendorfer, D., Asimow, P.D., 2022. Earth Planet. Sci. Lett., 584: 117500.