Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.35941

The evolution of carbonatite melts: combining experimental and natural constraints

SIMONE MARIONI AND MAX W SCHMIDT
ETH Zürich

Carbonatite - alkaline silicate melt systems are a key expression of volatile-rich, silica-undersaturated magmatism. These associations have been studied to retrieve information on the role of volatiles in the mantle [1], and to constrain the formation of economic rare earth element (REE) deposits [2]. While experiments indicate an origin of carbonatite melts mainly through liquid immiscibility [3], their exact composition and evolution remains mostly obscure as carbonatite rocks do not represent carbonatite melt compositions. Carbonatite rocks are characterized by low alkalis (< 1 wt.% bulk), due to their cumulative character, or rapid alteration [3]. While failing to preserve magmatic volatiles, the natural carbonatite record presents a variety of minerals whose composition bears information on the evolution of carbonatite magmas and related deuteric fluids. In this work, we experimentally constrain the sodium partition coefficient between apatite and carbonatite melt at subvolcanic conditions (800-1000°C, 0.1-0.2 GPa) as 0.010 ± 0.003, a value which is constant as long as the apatite remains REE- and S-poor. This result applied to the global database of apatites indicates 10-20 wt.% Na_2O for calcic carbonatite melts, and 25-30 wt.% Na_2O for dolomite-forming carbonatites. Integrating these constraints in a natural case study on the calcite- to dolomite- to ferro-carbonatite sequence of the Marinkas Quellen complex (SW Namibia) reveals a crystallization sequence for carbonatite melts starting with calcite, followed by magnesian dolomite, and then dolomite-ankerite with increasing FeO and MnO contents. These carbonatites have mantle-like Sr, C, and O isotopes. The Marinkas Quellen ferro-carbonatites instead, with up to 2.5 wt.% bulk REE_2O_3 represent the products of deuteric fluids overprinting late-stage magmatic rocks, as indicated by strongly changed Sr, C, and O isotopes.

[1] Fischer et al. (2009), *Nature* 459, 77-80.
[2] Anenburg et al. (2021), *Elements* 17, 327-332.
[3] Schmidt et al. (2024), *J. Petrol* 65, egae105.