Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37909

# The role of magmatic recharge in modulating major element evolution and REE enrichment in alkaline-silicate rocks: a case study of Erongo, Namibia

**CAROLINE R SODERMAN**[1], CORINNE FRIGO[1], OWEN M WELLER[1], CHARLES D BEARD[2] AND TERESA UBIDE[3]

[1]University of Cambridge
[2]Utrecht University
[3]The University of Queensland

Alkaline-silicate igneous complexes worldwide demonstrate substantial compositional diversity in their evolved rocks, from nepheline syenites to granites. While fractional crystallisation, pressure and redox conditions and crustal assimilation are known contributors to this heterogeneity [e.g. 1], the role of magma recharge in modulating major and trace element budgets in these systems remains poorly studied. Here, we investigate how the interplay of recharge and crystallisation influences the petrogenesis of alkaline systems, using the Erongo Complex (Namibia) as a case study.

Erongo is a ~35km diameter volcanic-plutonic complex associated with the Etendeka-Parana large igneous province. Here we focus on a suite of alkaline basanite-tephrite plugs, formed during the final stage of magmatic activity, which represent a co-magmatic series formed at shallow crustal levels with minimal crustal contamination [2]. Unlike many contemporaneous Namibian alkaline complexes, these plugs lack REE-mineralisation or association with carbonatites. Crucially, the suite contains abundant concentrically-zoned clinopyroxene —robust recorders of recharge [3].

Petrographic observations, EPMA transects and LA-ICP-MS trace element maps reveal that even the most primitive samples underwent multiple recharge events. In clinopyroxene, these events are marked by Cr peaks correlating with decreases in Fe#, $Fe^{3+}$, and $Al_T$, alongside drops in REE concentrations. Combined with the lack of overall REE enrichment from clinopyroxene core to rim, these observations suggest that the regular injection of primitive, REE-poor melt modulated the enrichment typically expected during fractional crystallisation.

We then employ phase equilibria modelling using new thermodynamic models for hydrous alkaline systems (modified from [4]) to constrain petrogenetic conditions. By integrating dynamic (composition and temperature-dependent) trace element partitioning, our models successfully reproduce the REE profiles observed in zoned clinopyroxenes. Our results also demonstrate that frequent magma recharge significantly dampens REE enrichment (especially LREE) in the evolving melt. Consequently, we propose that magma recharge must be considered alongside crustal assimilation and crystallisation as a key control on whether an alkaline complex becomes mineralised or remains barren.

[1] Soderman et al. (2025) Nat. Geo. 18(6), 555–562
[2] Trumbull et al. (2003) J. Petrology 44(1), 93–112
[3] Ubide et al. (2019) GCA 251, 265–283
[4] Weller et al. (2024) J. Petrology 65, egae098