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Unraveling magma dynamics of silica-undersaturated melts in transcrustal systems: a case study on clinopyroxene from the Pariquera-Açu Suite (SE Brazil)

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Small bodies of silica-undersaturated alkaline rocks, derived from enriched mantle sources, are widespread in southeastern Brazil. The sources of these rocks have been extensively studied and different alkaline series have been linked to mantle heterogeneities. However, the dynamics of melt transit through the continental crust remain poorly understood. The Pariquera-Açu alkaline suite is a fossilised alkaline intrusion zoned from mafic shonkinites in the margin to dominant malignites in the center, and with local manifestations of nepheline syenite, monzonite and tephrite. With a small area of ~4 km^2, it represents an ideal natural laboratory to elucidate the interaction of basanite and phonolite melts through recharge and mixing in a trans-crustal system. To decipher the composition of individual melt batches and their storage depths, we analyse and mapped zoned clinopyroxene crystals for major elements (electron microprobe) and trace elements (LA-ICP-MS). We identify four different clinopyroxene populations: Cpx1a) Augite-diopside cores with high Mg# (92-82) and Cr_2O_3 (6150-1643 ppm). Cpx2) Dominant Ti-rich diopside mantles/rims with intermediate Mg# (82-72), low Cr_2O_3 (530-27 ppm), brown colour and common sector zoning. Cpx1b) Augite-diopside intermediate bands mantling Cpx2 compositions, with high to intermediate Mg# (89-77) and Cr_2O_3 (4745-639 ppm). Cpx3) Greenish aegirine-augite reaction rims, with low Mg# (76-55) and Cr_2O_3 (207-2.9 ppm). Cpx1a-b and Cpx2 compositions have parallel, convex-upwards REE patterns and LREE enriched 3-40 times over primitive mantle, in equilibrium with mafic alkaline melts. Cpx3 rims are distinctly enriched up to 200 times over primitive mantle, and have negative europium anomalies (Eu/Eu*=0.7), suggesting a genetic link to phonolites. Crystallisation pressure calculated using the GAIA thermobarometry model indicate Cpx1a crystallized at ~6 kbar. Then, mafic melts migrated to a shallower emplacement level, evolving and crystallizing Cpx2 at ~0.5 kbar. Frequent replenishment with primitive basanite melts formed Cpx1b bands and generated the dynamic environments reflected in sector zoning. Subsequently, injections of phonolite liquid formed reaction rims (Cpx3). Polybaric mixing and ascent unveiled from our field to crystal-scale study may be globally applicable to the evolution of alkaline melts, indicating a complex open-system history that should be considered prior to discussions of mantle sources.

Zoned Clinopyroxene in Malignite