New constraints on trace element partitioning between minerals & alkaline melts

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Oldoinyo Lengai (Est African Rift, Northern Tanzania) is an active carbonatite-phonolite volcano and a natural laboratory to study the REE concentration processes along the liquid line of descent, and the distribution of critical metal resources at an alkaline complex. In order to provide the community with quantitative tools to quantify the REE (and other trace elements) concentration process, we have quantified element partitionning between alkali-rich phonolite melt and clinopyroxene (Cpx), nepheline (Neph), garnet (Grt), apatite (Ap) and wollastonite (Woll). All those phases are widespread in alkaline systems and their crystallisation clearly govern the enrichment of associated residual melts. Partition coefficients are eventually choice tools to understand alkaline magma differentiation.

In alkaline rocks and carbonatites, Cpx display sinusoidal REE pattern with unusual enrichments in heavy REE (HREE) and in Zr-Hf. Based on our new results we show that the specific D_{REE} partitioning of Cpx in some alkaline systems (D_{La}: 0.01, D_{Ho}: 0.06, D_{Ho}: 0.4) is not consistent with the standard models assuming incorporation of all REE in the M2 site; rather HREE substitutes both in M1 and M2 sites. HREE incorporation in M1 site is strongly dependant of Cpx chemistry (Fe^{3+}, Mn, Mg, Al^{IV}). A parametrized model based on Cpx major element composition is also provided.

New results on the partitionning of trace elements between alkaline melts and Grt, Ap, and Neph also provide the community with important data to quantify REE fractionation in alkaline-rich magmatic series. More specifically, we show that D_{REE} varies from 0.2 (D_{La}), to 15 (D_{Lu}) for Grt (Ti-andradite), from 5 (D_{La}) to 1 (D_{Lu}) for Ap, and from 0.006 (D_{La}) to 0.001 (D_{Lu}) for Neph. Rb (0.7), Sr (0.12) and Nb (0.001) are also incompatible elements in Neph.

The first partition coefficients between Woll and silicate melts are also provided. We highlights the strong incompatibility of Zr and Nb in Woll ($D < 0.01$), and various behaviour for REE partition coefficients increasing from D_{La} = 0.2 to D_{Lu} = 3. The crystallization of Woll eventually strongly influence REE fractionation during magmatic differentiation of alkali-rich melts and should therefore be considered if we are to fully understand trace element evolution and partitioning in alkaline magma series.