Experimental constraints on Fe isotope fractionation in a carbonatite melt system

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Carbonatite magmatism provides a highly efficient mechanism for transport from mantle to crust, thus allowing for insights into the chemistry and dynamics of the Earth's mantle [1]. Iron isotope data from natural carbonatite rocks show the largest variability found in igneous rock to date [2]. As such, Fe stable isotopes are a promising tracer for interaction of carbonate and silicate magmas in the mantle, particularly because Fe isotope fractionation is controlled by oxidation state and bonding environment [3]. Interpretation of data from natural carbonatite rocks [2] is still hampered for two main reasons: 1) The partitioning behavior of Fe between immiscible silicate melt and carbonate melt is largely unknown and 2) the Fe isotope fractionation between these compartments are to date assessed by theoretical calculations only [4] and lack experimental constraints.

We present results from equilibration experiments between silicate and carbonate melts at 1200°C and 0.7 GPa in an internally heated gas pressure vessel at intrinsic redox conditions. The silicate melt quenched to a glass whereas the carbonate melt formed finegrained quench crystals. The silicate and carbonate run products were seperated chemically by sequential extraction and mechanically by picking. Fe isotope compositions were then analysed by solution MC-ICP-MS.

Our first experimental results demonstrate, that in an alkali rich carbonatite system Fe is partitioned in nearly equal shares between silicate and carbonate immiscible melts. The Fe isotopes show a remarkable fractionation of $\Delta^{56}\mathrm{Fe}_{\mathrm{sil.melt-carb.melt}} = 0.41 \pm 0.07$ ‰. Thus, experimental results predict distinct Fe isotope signatures in carbonatites. These findings provide experimental support for a previously published model [2] for carbonatite genesis and evolution, where extremely negative δ^{56}Fe values in carbonatite rocks are produced by crystal fractionation and liquid immiscibility.

[1] Jones *et al.* (2013) *Rev. Mineral. Geochem.* **75**, 289-322. [2] Johnson *et al.* (2010) *Miner. Petrol.* **98**, 91-110. [3] Beard & Johnson (2004) *Rev. Mineral. Geochem.* **55**, 319-357. [4] Polyakov & Mineev (2000) *Geochim. Cosmochim. Acta* **64**, 849-865.