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Quantifying equilibrium mass dependent fractionation at high temperatures: Learnings from Neodymium (and where to next)...

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Non-traditional stable isotope geochemistry has moved forward rapidly to now encompass nearly the entire periodic table. The application of REE stable isotopes, and in particular Nd stable isotopes, which simultaneously provides a stable (process) and radiogenic (source) tracer information, has shown exceptional promise to enhance our understanding of REE behaviour in both high and low temperature contexts [1-4]. This talk will focus on what we know so far about the fractionation of Nd in high temperature igneous systems from both natural samples and theoretical predictions.

The refractory, lithophile and incompatible behaviour of Nd makes it useful for elucidating the geochemical evolution of planetary bodies. Most basaltic rocks show limited variability in δ^{146}Nd [1, 5, 6], which allowed the composition of the bulk silicate Earth to be constrained at -0.024 ±0.031‰ [5]. Due to the relatively high mass and its monovalent nature limited fractionation of Nd is predicted during normal magmatic process (i.e. fractional crystallisation and partial melting; mostly <0.03‰; [5, 7]). However, contrary to these predictions significant variations up to 0.15‰ are observed in some igneous systems [7, 8], which have been attribute to magmatic disequilibrium and kinetic diffusion [7, 9].

To increase our understanding density functional theory has been used to model minerals where REE are major cations (e.g. monazite and bastnäsite) but also common host minerals like (e.g. titanite or apatite) in which lanthanides REE substitute other cation metals. Our calculations are in excellent agreement with previous determinations for Ce [10]. Excluding for Nd in zircon, isotope fractionation between Nd^{3+} in silicate melts and accessory minerals remains limited (<0.015‰) at higher temperature regimes relevant for melts (>600°C). This limited fractionation provides both exciting opportunities and complications.

References

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