

# Origins of non-equilibrium lithium isotope fractionation in xenolithic peridotite minerals

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Olivine (ol), clinopyroxene (cpx) and orthopyroxene (opx) in Tanzanian peridotite xenoliths show systematic offsets in their Li isotopic compositions ( $\delta^7\text{Li}$  in ‰), with ol being heaviest (average +4.5), followed by opx (+0.8) and cpx (-1.3). There is no correlation between inter-mineral fractionations and equilibration temperatures (~850 to 1400°C), eliminating T-dependent equilibrium fractionation as their cause. These fractionations must thus be due to other processes, whose influence may be particularly evident in Li isotopes due to their extreme and differential diffusivity (D) [e.g., 1,2]. Such processes include (1) diffusion-driven exchange between peridotite minerals and a more Li-rich mantle melt, (2) recent heating and attendant inter-mineral Li redistribution and (3) diffusion of Li from the host basalt into the xenolith. Evidence for (1) is seen in silicate melt-metasomatised xenoliths from the Labait volcano, which show correlations between Li,  $\delta^7\text{Li}$  and Mg# in ol, but no correlations in cpx. These observations suggest faster Li diffusion in olivine than in cpx, analogous to the behaviour of Mg [3], and equilibration between the melt and olivine.

Modelling of this process, using  $D^{\text{cpx}}$  of  $10^{-12}$  [2] and  $D^{\text{ol}}$  of  $10^{-10}$  (by analogy with Mg [3]) shows that during Li ingress,  $\delta^7\text{Li}$  of ol initially decreases strongly, then quickly adopts the  $\delta^7\text{Li}$  of the melt (~10 y). Cpx lags behind (~10 ky). Thus diffusion of Li from a melt into peridotite, occurring several thousand years before entrainment of the xenolith, may produce the degree of isotopic offset observed in these samples. In this case, ol is a more faithful recorder of  $\delta^7\text{Li}$  of the metasomatising melt than cpx. Coupled  $\delta^7\text{Li}$ , Li and Mg# in ol further indicate negligible interaction with the host basalt, with a maximum magma residence time of 10 days.

Decoupling of Li and  $\delta^7\text{Li}$  in ol and systematically lower  $\delta^7\text{Li}$  in cpx (as observed in other Tanzanian xenolith localities) may suggest very recent heating (1-10 years, concentration contrast 1 ppm), whereby Li diffuses from ol into cpx, leaving heavier Li in ol and lighter Li in cpx, or reaction with a melt, either during or prior to entrainment (<10 days, 9 ppm). These two processes may be distinguished on the basis of Li concentrations, with the latter expected to produce higher overall concentrations in the minerals.

## References

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