

Sodic pyroxene and sodic amphibole as potential micro-analytical reference material for Li isotopes

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Two large pegmatitic crystals of sodic pyroxene (aegirine) and sodic amphibole (arfvedsonite) from the agpaitic igneous Ilímaussaq Complex, South Greenland are suitable reference materials for in-situ Li isotope analyses.

Li concentrations [Li] and isotope compositions ($\delta^7\text{Li}$) determined by SIMS and micro-drilled material analyzed by MC-ICP-MS generally agree within analytical uncertainty. The arfvedsonite crystal is homogeneous with [Li] = 639 ± 51 $\mu\text{g/g}$ (2σ , $n = 69$, MC-ICP-MS and SIMS results) and a mean $\delta^7\text{Li}$ of $+0.7 \pm 1.2$ ‰ (2σ , $n = 10$, via MC-ICP-MS) or -0.5 ± 1.1 ‰ (2σ , $n = 23$, via SIMS). Accordingly, we propose adopting of $\delta^7\text{Li} = 0$ ‰ for this crystal.

The aegirine crystal shows strongly developed sector zoning, which is a common feature of aegirines. Using qualitative element mapping techniques (EPMA), the homogeneous core of the crystal is easily distinguished from the outermost sectors of the crystals. The core has mean [Li] of 50.5 ± 3.6 $\mu\text{g/g}$ (2σ , $n = 33$) as determined by SIMS, whereas the seven micro-drilled regions measured by solution MC-ICP-MS returned slightly lower concentrations, between 41 and 46 $\mu\text{g/g}$. The $\delta^7\text{Li}$ of the core determined by SIMS (-3.4 ± 1.6 ‰, 2σ , $n = 5$) is in excellent agreement with the MC-ICP-MS data (-3.7 ± 1.2 ‰, 2σ , $n = 7$).

A limited quantity of these two crystals will be available upon request.

Kinetic Li isotopic fractionation in the alkaline plutonic Ilímaussaq complex, South Greenland

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Li concentrations [Li] and isotopic compositions ($\delta^7\text{Li}$) of mafic minerals (mainly amphibole and clinopyroxene) from the alkaline to agpaitic Ilímaussaq complex, South Greenland, track the behavior of Li and its isotopes during magmatic differentiation and final cooling of an alkaline plutonic system.

[Li] in amphiboles increase with magmatic differentiation from about 10 ppm in Ca-amphiboles of the least differentiated unit to >3000 ppm in Na-amphiboles of the highly evolved units. In contrast, clinopyroxenes are generally low in Li (15 – 84 ppm) and show no systematic variation with differentiation. The most important factors influencing the distribution of Li between these two phases appear to be changes in the major element composition of the minerals and changes in oxygen fugacity during differentiation. $\delta^7\text{Li}$ of all minerals span an extremely wide range from +17 to -8 ‰, with the different intrusive units having distinct Li isotope systematics.

Amphiboles from the inner part of the complex have constant $\delta^7\text{Li}$ of $+1.8 \pm 1.1$ ‰ ($n=15$) indicating a homogeneous melt reservoir, consistent with their mantle derivation and in agreement with published O and Nd isotopic data. Clinopyroxenes of these samples are consistently lighter, with $\Delta^7\text{Li}_{\text{amph-cpx}}$ as large as 8 ‰ and are thus not in Li isotopic equilibrium. These light values might reflect late-stage diffusion of Li into clinopyroxene during final cooling of the rocks, thus enriching the clinopyroxene in ^6Li .

At the margin of the complex $\delta^7\text{Li}$ increases systematically, from +2 to exceptionally heavy values of +17 ‰. This, coupled with the observed Li isotope systematics of the granitic country rocks, whose $\delta^7\text{Li}$ dips to -9 ‰ 5 m from the contact and rebounds to +4 ‰ over 100 m away, supports post-magmatic open-system processes occurring during final cooling of the Ilímaussaq rocks. The country-rock profile reflects fluid infiltration from, and Li diffusion out of, the complex. In contrast, the fractionation within the pluton is too large and not of the right shape to represent diffusional loss of Li. Instead, the extremely heavy values reflect the ingress and circulation of an external fluid phase with a high $\delta^7\text{Li}$ value (possibly seawater) along the chilled contact. This study demonstrates the power of Li isotopes in deciphering fluid- and diffusion-governed processes.