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The Cl isotope variation of sodalite and eudialyte in Ilímaussaq (South Greenland)

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Sodalite ($Na_8Al_6Si_6O_{24}Cl_2$) and eudialyte ($Na_{15}Ca_6Fe_3Zr_3Si_{26}O_{72}(O,OH,H_2O)_4Cl_2$) are abundant Cl-rich minerals in the extremely evolved peralkaline rocks of the Ilímaussaq intrusion and because of locally high Be contents during hydrothermal conditions, the rare Be silicate tugtupite ($Na_8Be_2Al_2Si_8O_{24}Cl_2$) occurs as well. We measured their Cl isotope composition (see Figure) in order to understand Cl isotope variations and fractionation between minerals in magmatic and hydrothermal systems. We presume that these minerals crystallise from the melt and the hydrothermal fluids in isotopic equilibrium, comparable to the processes that precipitate salt minerals from brine, and that little or no isotope exchange takes place after the crystallisation of the minerals. Magmatic sodalite and eudialyte crystallised from a peralkaline melt at high temperatures (e.g. 800-600 °C [1]), hydrothermal sodalite and tugtupite formed at lower temperatures (e.g. 500-300°C [2]).

Equilibrium isotope fractionation between melt and Cl minerals is not well understood yet, although recent studies suggest that sodalite crystallises with a negative fractionation factor ($1000\ln\alpha \approx -0.3$) with respect to the melt [3,4]. This indicates that the reduced partition function ratios (β) for sodalite are lower than for the melt. Unfortunately, no β-functions are known for eudialyte and tugtupite, but a recent study [5] suggests that the β-function decreases when the Na-Cl bond length in the crystal increases. As Na-Cl bond lengths in eudialyte (2.8-2.9Å) and tugtupite (2.7-2.8Å) are comparable to those from sodalite (2.7-2.9Å) this suggests that β-functions and thus isotope fractionation are of the same order of magnitude. These data suggest that, based on observed $\delta^{37}Cl$ values between 0 and 0.5‰, the $\delta^{37}Cl$ of the melt was between 0.5 and 1‰. These values agree well with the range observed for the enriched mantle [6].

References:

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