Chlorine isotope behavior in subduction zone settings: insights from olivine-hosted melt inclusions and bulk rocks

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Chlorine is a highly hydrophile and incompatible element which may provide insights into the transfer of elements from the slab to the surface in subduction zone settings. Bulk rocks data have shown that δ^{37}Cl are effective tracers of subducted fluids influence in volcanic rocks, with δ^{37}Cl variation up to 3‰ along an arc (Barnes et al., 2009). Nevertheless, a more profound comprehension is needed to identify the specific contributions from the different slab lithologies. Recent advancements in secondary ion mass spectrometry (SIMS) enable precise determination of δ^{37}Cl values at high spatial resolution. In situ measurements of olivine-hosted melt inclusions provide a first order constraint on the δ^{37}Cl of primary magmas since these melt droplets are unaffected by near surface processes.

Chlorine isotopes varies by more than 2‰ within a single rock sample. Indeed, combined with either other stable isotopes systems or trace elements within the same melt inclusions, it is possible to trace the signature of the different Cl sources beneath the studied volcanic centers. (Bouvier et al., 2019; Bouvier et al., 2022b). Within an entire arc, the range of δ^{37}Cl measured in melt inclusions can be as large as 5‰ (Bouvier et al., 2022a). From arc to arc, the average δ^{37}Cl measured in melt inclusions varies, with a possible link between δ^{37}Cl and the upper plate thickness, which remains to be confirmed and understood. Intriguingly, when we compare δ^{37}Cl values from bulk rocks with those obtained in situ from the same volcano, discrepancies occasionally emerge. These deviations cannot be ascribed solely to instrumental biases. Instead, the difference between bulk rocks and melt inclusions suggests that the latter preserve undegassed signatures which might be lost in bulk rocks. Melt inclusions can thus be very useful to: (i) better constrain the behavior of Cl and δ^{37}Cl in subduction zone settings, in particular during fluid-rock interaction within the mantle wedge; and (ii) track the influence of amphibole in the context of arc magma genesis and differentiation.

References:

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