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Chlorine cycle in subduction zone settings: insights from chlorine isotopes in olivine-hosted melt inclusions and bulk rocks

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Chlorine (Cl) 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 Cl stable isotopes ($\delta^{37}\text{Cl}$) are effective tracers of subducted fluids influence in volcanic rocks, with $\delta^{37}\text{Cl}$ 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 $\delta^{37}\text{Cl}$ values at high spatial resolution. In situ measurements of olivine-hosted melt inclusions provide a first order constraint on the $\delta^{37}\text{Cl}$ of primary magmas since these melt droplets are unaffected by near surface processes.

Chlorine isotopes measurements in melt inclusions from arc samples have revealed large variation within a single rock sample (more than 2‰), and even larger considering melt inclusions from different rock samples along a single arc (up to 5‰). The combination of these data with O and B stable isotopes or with trace elements, measured within the same melt inclusions, suggest that the intra-sample and along-arc variations are related to variable influences of different Cl sources (Bouvier et al., 2019; Bouvier et al., 2022a,b). Indeed, the lowest $\delta^{37}\text{Cl}$ values (down to -3.4‰) usually reflect the imprint of subducted sediments, whereas the highest $\delta^{37}\text{Cl}$ values (up to -3.1‰) might reflect the presence of amphibole in the mantle source. Intriguingly, when we compare $\delta^{37}\text{Cl}$ values from bulk rocks with those obtained in situ in melt inclusions 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. In situ measurement of $\delta^{37}\text{Cl}$ in melt inclusions can thus be very useful to: (i) better constrain the behavior of Cl and $\delta^{37}\text{Cl}$ in subduction zone settings, in particular during fluid-rock interaction within the mantle wedge and during degassing, and (ii) track the influence of crystallization/dissolution of Cl-rich minerals in the

context of arc magma genesis and differentiation.

References:

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