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Sources and Processes Controlling $\delta^{37}Cl$ in Arc Magmas: New Constraints from the Lesser Antilles

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The Lesser Antilles arc, generated by westward subduction of the Atlantic Plate beneath the Caribbean Plate, is well characterized in terms of lava geochemistry and crustal structure (e.g., [1] for a review). Slab contribution varies markedly along the arc, from pelagic sediments in the north, to fluids from serpentinite in the center, and continental sediments in the south, providing an ideal natural laboratory to investigate chlorine isotope behavior in subduction zones.

We analyzed rhyolitic melt inclusions hosted in pyroxenes from 9 samples spanning Guadeloupe, Martinique, and Dominica. Chlorine and oxygen isotopes were measured in situ at the SwissSIMS laboratory (University of Lausanne). Despite limited variability in major-element compositions, melt inclusions display a wide range of $\delta^{37}Cl$ (-2.4 to +2.6 ‰) and $\delta^{18}O$ (5.8 to 13.9 ‰), with no correlation with Cl content. Compared with published data from St. Vincent in the southern arc [2], both $\delta^{37}Cl$ and $\delta^{18}O$ values decrease systematically from south to north, similar to the along-arc trend previously documented for $\delta^{11}B$ and attributed to changes in slab-derived components [3]. This parallel behavior supports the potential of Cl isotopes to trace distinct slab signatures.

In Guadeloupe, the melt inclusions from the two investigated eruptions show overlapping $\delta^{37}Cl$ ranges, implying similar Cl sources. In contrast, Martinique melt inclusions display inter-eruption $\delta^{37}Cl$ variations that correlate with published H_2O contents, suggesting temporally variable fluid inputs over 1000 years. Dominica samples exhibit the largest $\delta^{37}Cl$ variability, which appears linked to amphibole presence: melt inclusions from amphibole-bearing samples show average $\delta^{37}Cl$ values up to 2 ‰ lower than those from amphibole-free samples, despite similar major-element, Cl, and $\delta^{18}O$ characteristics.

These results highlight the ability of in situ $\delta^{37}Cl$ measurements to reveal both along-arc and temporal variations in Cl sources. The relationship between mineralogy and $\delta^{37}Cl$ values will be explored in the context of several potential processes, such as brine exsolution, hydrothermally altered crust assimilation, and amphibole crystallization.

References :

[1] Balconne-Boissard et al. (2023), Journal of Petrology 64, 1-78

[2] Bouvier et al. (2019), Earth and Planetary Sciences Letters 507, 30-39

[3] Cooper et al. (2020), Nature 582, 525-529