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Chlorine isotopes in La Soufrière de Guadeloupe (FWI) fumaroles trace HCl scrubbing at shallow depth

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For volcanoes with large hydrothermal system, it is challenging to constrain the initial volcanic gases composition (i.e. before hydrothermal interaction) particularly for SO_2 and HCl because of their solubilization in waters (scrubbing). Chlorine is highly soluble in waters and chemically considered as mainly non-reactive (unlike SO_2), and thus can inimitably trace interactions between gases and waters. Furthermore, large Cl isotope fractionations in volcanic systems should only occur during evaporation and/or vapor condensation [1].

Here, we investigate for the first time the potential of δ37Cl to constrain scrubbing on a suite of samples (condensates and Giggenbach bottles collected from 2018 to present) from la Soufrière de Guadeloupe (FWI) summit fumaroles. This volcano has developed a large hydrothermal system in which transient thermobarometric fluctuations may determine rapid accelerations of the ongoing unrest [2]. This activity culminated in April 2018 with the occurrence of a 4.1M earthquake, which was considered as a failed phreatic eruption determined by the hydrothermal overpressure due to a magmatic gas pulse [2].

We find δ37Cl preliminary data of fumarolic samples that vary from 0.6 to 11.7‰. To interpret this variation, we designed an HCl boiling experiment that shows that vapor/liquid chlorine isotopes partitioning occurs at thermodynamic equilibrium over boiling, with a fractionation of $\Delta_{vapor\text{-}liquid}$=1.5‰. Assuming that the deep aquifer brines have δ37Cl of -1‰, based on summit acid pond δ37Cl value, we calculate that the starting δ37Cl value of HClgas is ~0.5‰ prior to subsurface scrubbing. Assuming that partial HClgas condensation via scrubbing occurs under the same equilibrium conditions than boiling and follows a Rayleigh distillation law, we model the δ37Cl value of remaining HClgas for every HClgas lost fraction. Fumarolic samples with δ37Cl from 0.6 to 11.7‰ would require 6 to 99% HClgas removal via subsurface scrubbing. Further investigations will help to refine these quantifications and to better understand why scrubbing rates vary so much. Our δ37Cl dataset will also be closely compared to more conventional geochemical indicators of volcanic gas compositions [2] to link the observed δ37Cl variations with magmatic and rainfall forcing.

References:
[1] Schauble et al. 2003, GCA
[2] Moretti et al., 2020, JVGR