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Geochemical markers of magmatic solicitations to volcanic-hydrothermal systems: the long-standing unrest of La Soufrière de Guadeloupe dissected via non-condensable gases

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Interpretation of geochemical time-series is a major issue for decrypting volcano dynamics and forecast eruptive scenarios at volcanoes in unrest. However, interpretation cannot be purely observational and rquires the assessment of the main physicochemical features of the magmatic-hydrothermal system. In the case of La Soufrière of Guadeloupe (FWI) andesitic volcano, a careful analysis of different techniques adopted historically for gas sampling and analysis by the local observatory has allowed us to model magmatic degassing and assess gas indicators from non-condensable species in the H_2-N_2-CH_4-He-Ar system available since 2006 and discharged by low-T fumaroles. Here we report on the hydrothermal build-up of pressure and temperature modulated by magmatic variations, essentially decompression, in a gas compositional space resulting from the mixing of atmospheric component with a magmatic-hydrothermal gas evolving along a lineage connecting MORB-like upper mantle and arc-volcano components. Two main regimes are recognized: one is about hydrothermal degassing conditions perturbed by the deep and impulsive gas infiltration after magma refilling in a 4 to 8 km deep chamber; the other is determined by ascent of magma batches to a shallower (about 3 km deep) chamber. Further changes of the bulk permeability structure in the hydrothermal reservoir due to fracture sealing and clogging effect may exacerbate observed evolutions but do not represent the primary control of the degassing process. We also show that gas ratios in the H_2-He-CH_4 subsystem can effectively discriminate and anticipate such tendencies and, particularly, they can be turned into reliable precursors of magma-derived solicitations and set possible thresholds for next crises. The main test is made with respect to past episodes of accelerated unrest for which geophysical observables and other reliable geochemical indicators in the CO_2-CO-CH_4-H_2O-H_2 system are available [1]. The presented method allows a full backtracking of the magmatic-hydrothermal evolution since 2006. Our results and conclusions are suitable for all those volcanic systems at the hydrothermal stage and allow a better definition of unrest scenarios whenever sampling frequency of fumarolic fluids is compatible with the expected transit times of magmatic fluids from magma chambers to surface.

[1] Moretti et al. (2020) JVGR, *393*, 106769.