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Steam and gas emission rates from La Soufrière of Guadeloupe (Antilles arc): implications for the magmatic supply degassing during unrest

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Since its last magmatic eruption in 1530 AD, La Soufrière andesitic volcano in Guadeloupe has displayed intense hydrothermal activity and six phreatic eruptive crises (the last of which, in 1976-1977, with 73000 evacuees). Here we report on the first direct quantification of gas plume emissions from La Soufrière summit vents, which gradually intensified during the past 20 years. Gas fluxes were determined in 2006 then 2012 [1] by measuring the horizontal and vertical distribution of volcanic gas concentrations in the air-diluted plume, the composition of the hot fumarolic fluid at exit (108°C), and scaling to the speed of plume transport (in situ measurements and FLIR imaging). We first demonstrate that all fumarolic vents of La Soufrière are fed by a common H_2O-rich (97-98 mol %) fluid end-member, emitted almost unmodified at the most active South Crater while affected by secondary alterations (steam condensation, sulphur scrubbing) at other vents. Daily fluxes in 2012 (200 tons of H_2O, 15 tons of CO_2, ∼4 tons of H2S and 1 ton of HCl) were augmented by a factor ∼3 compared to 2006, in agreement with increasing activity. Summit fumarolic degassing contributes most of the bulk volatile and heat budget (8 MW) of the volcano. Isotopic evidences demonstrate that La Soufrière hydrothermal emissions are sustained by continuous heat and gas supply from an andesitic magma reservoir confined at 6-7 km depth. This magmatic supply mixes with abundant groundwater of tropical meteoric origin in the hydrothermal system. Based on petro-geochemical data for the erupted magma(s), we assess that the volcanic gas fluxes in 2012 can be accounted for by the release of free magmatic gas derived from about 1000 m3 per day of the basaltic melt replenishing the reservoir at depth. In terms of mass budget, the current degassing unrest is compatible with enhanced free gas release from that reservoir, without requiring any (actually undetected) magma intrusion. We recommend a regular survey of the fumarolic gas flux from La Soufrière in order to anticipate the evolution of the magma reservoir.
[1] P. Allard et al., Chemical Geology 384, 76–93, 2014.