Geophysical Research Abstracts
Vol. 21, EGU2019-18548, 2019
EGU General Assembly 2019

The 2018 unrest phase at La Soufrière of Guadeloupe (French West Indies) andesitic volcano: scrutiny of a failed but prodromal phreatic eruption

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After 25 years of gradual increase, unrest at La Soufrière of Guadeloupe reached its highest seismic energy level on 27 April 2018, with the largest felt volcano-tectonic (VT) earthquake (ML 4.1 or MW 3.7) recorded since the 1976 phreatic eruption. This event marked the onset of a fourth seismic swarm (180 events, 2 felt) following swarms on January 3rd to 6th (70 events, none felt), February 1st (30 events, 1 felt) and April 16-17 (140 events, 1 felt). Many events were hybrid VTs with long-period codas, located 2-4km below and clustered within 2km of the volcano along a regional NW-SE fault cross-cutting La Soufrière. Swarm Elastic energy release increased with each swarm whereas inter-event time shortened. During this period, summit fractures continued to open and thermal anomalies extended. Fumarole fluxes increased significantly until 20th April when they reached a maximum of 80 m/s (on 2018-03-23) and 111.4°C (on 2018-04-03), before they started to decline, slowly after 22nd April, to ∼95°C and ∼33m/s on 25th April. Gas compositions revealed increased, high C/S and CO_2/CH4 ratios and track hydrothermal P-T conditions that reached the critical point of pure water. MultiGAS data revealed increased CO_2/H2S ratios and SO_2 contents in fumarole plumes, as well as the reactivation of degassing fractures (T=93°C, H2S/SO_2≈1). Although there is no direct evidence of upward magma migration, we infer that injection of magma and/or magmatic fluid heated and pressurized the bottom hydrothermal system. This triggered seismogenic hydro-fracturing, and likely induced changes in deep hydraulic properties (permeability) and drainage pathways, ultimately lowering fumarolic pressure and fluxes. Although this injection was modulated by the hydrothermal system during unrest, the unprecedented seismic energy release and critical point conditions of hydrothermal fluids suggest that the observed unrest phase can be regarded as a failed phreatic eruption. We warn that non-magmatic explosive activity could occur in the future should similar unrest phases reoccur, by destabilizing the shallow hydrothermal system that is currently responsible of 7-10mm/y of nearly radial horizontal displacements within 1 km from the dome. Its destabilization could also potentially trigger partial collapse of dome's SW flank, already affected by basal spreading above a decollement surface inherited from past collapses. Nevertheless, an evolution towards magmatic conditions cannot be excluded, considering that the analysis of conjugated geochemical indicators based on conservative gas species in the discharged fluids suggest that the infiltrating deep gas triggering the observed sequence of events is likely to have been released by deep fresh magma which in the future could resupply the shallow andesitic magma chamber dating back to the last major magmatic eruption of La Soufrière in 1530 AD.