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Trade-offs between deep (magmatic) and shallow (hydrological) forcings on volcanic unrest at La Soufrière de Guadeloupe (Lesser Antilles)

David Jessop[1,2], Roberto Moretti[1], Séverine Moune[1,2], and Vincent Robert[1]
[1]Université de Paris, Institut de Physique du Globe de Paris, Observatoire Volcanologique et Sismologique de la Guadeloupe, Gourbeyre, France (d.jessop@opgc.fr)
[2]Université Clermont Auvergne, Observatoire de Physique du Globe de Clermont-Ferrand - Laboratoire Magmas et Volcans, Aubière, France

Fumarolic gas composition and temperature record deep processes that generate and transfer heat and mass towards the surface. These processes are a result of the emplacement, degassing and cooling of magma and the overturning of the above hydrothermal system. A reasonable expectation, and too often an unproved assumption, is that fumarole temperatures and the deep heat sources vary on similar timescales. Yet signals from deep and shallow processes have vastly different temporal variations. This indicates that signals arising from deep activity may be masked or modified by intervening hydrothermal processes, such as fluid-groundrock reactions in which secondary minerals play a major role. Clearly, this complicates the interpretation of the signals such as the joint variation of fumarole vent temperature and geochemical ratios in terms of what is occurring at depth. So what do the differences between the timescales governing deep and shallow processes tell us about the intervening transport mechanisms?

At the volcanic dome of La Soufrière de Guadeloupe, the Observatoire Volcanologique et Sismologique de la Guadeloupe has performed weekly-to-monthly in-situ vent gas sampling over many years. These analyses reliably track several geochemical species ratios over time, which provide important information about the evolution of deep processes. Vent temperature is measured as part of the in-situ sampling, giving a long time series of these measurements. Here, we look to exploit the temporal variations in these data to establish the common processes, and also to determine why these signals differ. By fitting sinusoids to the gas-ratio time series we find that several of the deep signals are strongly sinusoidal. For example, the He/CH_4 and CO_2/CH_4 ratios, which involve conservative components and mark the injection of deep and hot magmatic fluids, oscillate on a timescale close to 3 years. We also analyse the frequency content of the temperature measurements since 2011 and find that such long signals are not seen. This may be due to internal buffering by the hydrothermal system, but other external forcings are also present. From these data we build up a more informed model of the heat-and-mass supply chain from depth to the surface. This will potentially allow us to predict future unrest (e.g. thermal crises, seismic swarms), and distinguish between sources of unrest.