The role of volatile bubbles in the cyclic dynamics of shallow volcanic systems

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Many volcanic systems exhibit an overall cyclic behaviour. This is suggested by observations of periodic variations in seismic activity, magma flow rates and ground inflations/deflations. Examples are found in Mount St. Helens, Santiaguito and Montserrat [1-3]. The period varies from a few hours to many years, depending on the volcano parameters. On the other hand, in an ascending magma, volatile components exsolve from the melt and form bubbles. The strong dependence of the magma viscosity with the volatile concentration generates a positive feedback on the magma flow.

We consider here the effect of the growth of volatile bubbles on the dynamics of a magmatic flow in a shallow volcanic system (so that temperature and crystal content variations are neglected). Various expressions for the bubble growth rate are used, thus generalizing previous work [4]. In particular, a many-bubble growth rate law that takes into account the presence of the other bubbles is considered [5]. For a range of volcanic parameters, the system undergoes a Hopf bifurcation, so that periodic solutions are generated (Fig. 1). This work can be used to constraint the parameters characterizing volatile bubble growth in shallow volcanic systems.

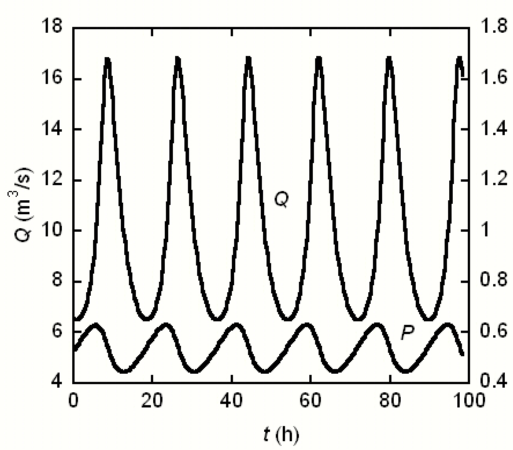

Figure 1: Magma flow rate *Q* and overpressure *P* at the base of the volcanic channel as a function of time *t* for a many-bubble growth rate law in a periodic regime.

[1] Voight *et al.* (1998) *Geophys. Res. Lett.* **25**, 3405-3408. [2] Barmin *et al.* (2002) *Earth & Planet. Sci. Lett.* **199**, 173-184. [3] Harris *et al.* (2003) *Bull. Volcanol.* **65**, 77-89. [4] Wylie *et al.* (1999) *Science* **285**, 1883-1885. [5] L'Heureux (2007) *J. Geophys. Res.* **112**, B12208.

Why are Martinique lavas so heterogeneous?

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Martinique lavas display a very large range of isotopic compositions and cover almost completely the entire history of the Lesser Antilles arc. The lava chemical compositions have been interpreted as the result of mixing processes between a mantle component and different proportion of a crustal component.

We measured Pb, Sr, Nd and Hf isotopic ratios on 30 age-constrained samples chosen to represent all phases of Martinique volcanic activity between 25 Ma and present. Lavas exhibit a range of isotopic compositions from values close to MORB to almost continental values: $^{176}Hf/^{177}Hf$ ratios range from 0.283163 to 0.282554, $^{206}Pb/^{204}Pb$ from 18.9888 to 19.9428 and $^{87}Sr/^{86}Sr$ from 0.703701 to 0.710033.

Samples define two significantly different mixing trends in all isotopic spaces. One trend is defined by the 'old' lavas from 25 Ma to 7 Ma and the other is defined by the 'recent' lavas, from 5 Ma to present. Regression lines and hyperboles allow us to constrain the end-members of the two mixing arrays. The two mantle sources have distinct $^{208}Pb/^{204}Pb$ ratios, similar Nd and Hf compositions and relatively radiogenic Sr isotopes. The two crustal components coincide with the local sediment compositions [1]. Nevertheless, sediments involved in the genesis of old lavas are more radiogenic than sediments involved in the genesis of recent lavas. The two mixing arrays suggest that not only variable inputs of sediments occur but also that both mantle and sediment end-members change. Between 7 and 5 Ma a sudden switch of sources occurred. This might be due to the subduction of an aseismic ridge that changed the geometry of melting sites in the mantle wedge.

[1] Carpentier *et al.* (2008) *EPSL* **272**, 199-211.