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Magma ascent dynamic through Ti diffusion in magnetites. Application to lava dome-forming eruptions. Implications to lava dome superifical explosivity.

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Superficial lava dome explosivity represents a major hazard during lava dome growth. But the origin of this explosive activity remains unclear until recently. By using geochemical (residual water content, silica abundance) and textural (vesicularity, microcristallinity) data, we constrain the occurrence of such hazard to the beginning of the lava dome activity. During the first stages of growth, the lava dome is small enough to develop an impermeable carapace that isolates a less degassed batch of magma inside, thus allowing an internal overpressurization of the volcano (Boudon et al., 2015). This study more precisely details the petrology and the texture of titano-magnetites as archive of magma ascent dynamic within the conduit. Titano-magnetites may exhibit two types of textures: exsolved or “limpid”. When they are exsolved, no time constrain may be extracted as they re-equilibrate. On the contrary, when they are unexsolved, major element distribution, in particular Ti, may act as a powerful tool to decipher magma dynamic (differentiation, mixing) and estimate time that corresponds to the magma ascent time. The composition and elemental diffusion profiles are acquired by EPMA, following textural investigations by SEM. The time is then obtained by modelling the profile as a diffusion profile using the intracristalline diffusion coefficients published in literature.
We applied this methodology to examples of lava dome superficial explosivity on Montagne Pelée in Martinique (Lesser Antilles Arc), and on Puy Chopine volcano in La Chaine des Puys, (French Massif Central). More precisely, the first phase of the Puy Chopine lava dome growth experienced a superficial explosion, as for Montagne Pelée, the first stages of the 1902 eruption (several superficial explosions occurred) and the 650 y. BP eruption (two superficial explosions destroyed the growing lava dome).
We show that, for a single event, the vesiculated, undegassed batch of magma responsible of the overpressurization of the growing lava dome may be distinguished from the magma building the impermeable carapace. Time of magma ascent is of the order of magnitude of 10 days before explosive activity. For a cyclic activity, as the 1902 eruption of Montagne Pelée, the evolution of magnetites composition associated to time investigation allow a better constrain of magma dynamic within an active volcano.

Boudon, G. et al. What factors control superficial lava dome explosivity? Sci. Rep. 5, 14551; doi: 10.1038/srep14551 (2015).