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Pulsatory degassing model of a static intrusion of silicic magma: application to geochemical monitoring of andesite volcanoes.

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Correlations between thermal springs compositions and shallow seismicity at La Soufrière of Guadeloupe (Lesser Antilles) since the 1975-77 volcanic crisis, have been interpreted as the result of a shallow magma intrusion degassing (Villemant et al. 2005). Gas injection pulses in the surficial phreatic system are characterized by the decrease with time of their frequency and of the gas loss rate, and a bulk duration after magma emplacement of $\approx$ 15 years. A general degassing model is proposed which reproduces this particular pattern: an acid andesitic magma is stored at shallow depth where it is water saturated. It cools vertically by laminar convection which leads to melt crystallization, volatile exsolution and gas overpressure. When the overpressure reaches a specific threshold, wall rocks fracture and gas excess is assumed to escape instantaneously. The intrusion returns to initial lithostatic pressure and a new cooling-crystallization-degassing cycle occurs. A series of such cycles leads to a pulsatory degassing regime. Three model output parameters can be compared to surface observations: the degassing pulse frequency, the cumulative expelled mass of gas and the duration of the bulk degassing process. The relative weight of the main input parameters (host rocks tensile strength σ_t, magma volume V and depth, initial temperature contrast between magma and wall rocks, and initial magma crystallinity) is evaluated. The evolution of the observable outputs with time, according to the crucial values of σ_t and V, is determined. For a particular andesitic intrusion, the knowledge of the degassing pulse frequency and either the cumulative expelled gas rate or the duration of the total crystallisation-degassing process, allows to estimate σ_t and V ranges, which are generally poorly known. The model is applied to the geochemical evolution of the Soufrière hot springs which allows to constrain the host rocks tensile strength and the size of the assumed magma intrusion during the last crisis.