

Rates of magma ascent at Mt. Etna volcano revealed by diffusion of volatiles in glasses and crystals

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A crucial parameter for determining the explosivity of an eruption is the magma ascent rate, which plays a key control on bubble nucleation, bubble growth and coalescence, affecting the degassing modes during syn-eruptive stages. Diffusion chronometry of elements characterized by high diffusivity in glasses and minerals can provide direct measurements of the kinetics of such short-lived processes. We propose an approach of investigation based on diffusion of compositional gradients of volatile species and light elements (H₂O, CO₂, S, Li) along olivine-hosted melt tubes and in various types of crystals. Application of diffusion modeling of volatile species into melt tubes yields to timescales over which volatiles have been exchanged by diffusion with the adjacent melt in response to the degassing-induced decompression. Modelling of multiple volatiles species allows to better constrain the process of magma ascent over a range of depths, which depends on the solubility of the species modelled. Li gradients in plagioclase reflect the gas phase separation just prior to the eruption that leads to rapid depletion of Li from the melt, causing in turn decrease of Li concentrations in plagioclase. Thus, diffusion modeling of Li concentration gradients in plagioclase leads us to recover timescales of the final stage of magma ascent and degassing just before the emission at surface. We are using such approaches to constrain the degassing and ascent histories of volatile-saturated magmas during some recent explosive eruptions occurred at Mt. Etna in the 2011-2018 period. The selected eruptions are characterized by different intensities and can be assumed as case studies in order to figure out a wide array of ascent rates for explosive eruptions at open-conduit volcanoes. Preliminary findings of our study indicate exceptionally short timescales (even less than 2 minutes) for the re-activation of the magmatic system at Mt. Etna, probably as a response of gas flushing processes. These results are comparable to timescales of syn-eruptive magma ascent derived for Plinian eruptions in closed-system.