Geophysical Research Abstracts
Vol. 21, EGU2019-18571, 2019
EGU General Assembly 2019

Interplay between rapid mixing and short storage at a steady-state volcano

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Steady-state volcanoes are characterised by equilibrium between the rate of magma input and output in an open conduit system resulting in compositionally homogeneous magmas. The equilibrium status can last for tens to thousands of years. The Present-day activity of Stromboli volcano (Italy) is typical of a steady-state volcano, with a shallow magmatic reservoir (hp-magma) continuously refilled by more mafic magma (lp-magma) at a constant rate, accompanied by mixing, crystallisation and eruption. In the effort to clarify timescale and dynamics of the plumbing system at the establishment of the Present-day steady-state activity, we investigated the Post-Pizzo (PP) pyroclastic sequence and one of the Early Paroxysms (EP) of the Present-day activity.

Complex compositional zoning of clinopyroxenes from both PP and EP indicates the existence of three different melt domains: a high-Mg# proto-lp recharging magma, a low-Mg# proto-hp resident magma, and a transient intermediate-Mg# magma. Repeated injections of the proto-lp magma in the shallow proto-hp magma reservoir originate turbulent flow fields and mixing regimes that produce the three melt domains. However, efficient (days to a few years) stirring and melt homogenisation (homogenisation time < residence time) allows the magmatic system to regain the pre-input proto-hp composition. This regime was established during the PP period and typically characterizes the Present-day activity (Petrone et al., 2018 EPSL).

Geospeedometry applied to Fe-Mg diffusion in clinopyroxene (NIDIS model, Petrone et al., 2016 Nat. Comms.) allows to calculate a total residence time from 1 to ∼50 years during PP and EP periods, from the arrival of the mafic magma in the shallow system until the eruption. The mafic triggering event of the feeding proto-lp magma occurring within few months to a few days before eruption is recorded by some clinopyroxenes from the PP. Finally, some clinopyroxene portions captured the on-going mixing and homogenisation process between the proto-lp and the proto-hp magmas leading to the eruption in only a few days. The interplay between rapid mixing and short storage timescales as captured by the lifetime history of clinopyroxenes of a typical steady-state volcano, such as Stromboli, suggests that this might be a common dynamics of the plumbing system of steady-state volcanoes (Petrone et al., 2018 EPSL).