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Rapid growth of plagioclase: implications for basaltic Plinian eruption

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Rock textures of volcanic products record the evolution of the conditions and processes that lead to their formation. Particularly, time is a paramount variable in volcanic processes because it is intimately linked with equilibrium vs disequilibrium processes [1-2]. During magma ascent in volcanic conduits, crystallization is controlled by degassing and cooling. The study of crystallization kinetics allows us to determine the disequilibrium conditions that affect the dynamics of magma in a conduit. This has strong implications on the hazard of volcanic systems. Here we performed for the first time the 4D (3D plus time) crystallisation kinetics, through fast synchrotron X-ray microtomography, in order to quantify plagioclase crystallization kinetics in basaltic magma. The experiments were performed at beamline I12 of Diamond Light Source, the UK synchrotron, Harwell. For these experiments we used the Alice furnace, small cylindrical chips of Etna 2001 basaltic glass, which were heated at the beamline up to 1250 °C for 30 minutes. After the initial annealing period, crystallisation was induced by isobaric decreasing temperature from 1250 °C to both 1170 °C and 1150 °C, and then holding at the final temperature for 4 h. After this step, a final cooling rate of 0.4 °C/s was imposed to the sample, simulating a possible rapid cooling induced by a fast magma ascent in the conduit before a Plinian eruption. Preliminary results on rapid crystal growth of plagioclase induced in these experiments provide values of ∼5x10-4 cm/sec, meaning that plagioclase can reach 500 μm of length in 90 seconds. Crystallization kinetics of basaltic Plinian eruptions are poorly constrained, therefore, these information are fundamental to better constrain the timescales of magma chamber-conduit processes, triggering and ascent. These are the first data ever produced on plagioclase crystallisation of basaltic magma in 4D. Data on crystallisation of basaltic magma are of fundamental importance to improve our understanding of processing affecting magma ascent and eruption dynamics, and therefore extremely valuable to improve our capacity of predicting eruptions and mitigating volcanic hazard.

[1] Arzilli, F. et al. (2015) Contrib. Mineral. Petrol. 170, 55. [2] La Spina, G. et al. (2016) Nat. Comm. 7, 13402.