Geophysical Research Abstracts
Vol. 18, EGU2016-15633, 2016
EGU General Assembly 2016

A temporal record of pre-eruptive magmatic volatile contents at Campi Flegrei: Insights from texturally-constrained apatite analyses

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Apatite is capable of incorporating all major magmatic volatile species (H_2O, CO_2, S, Cl and F) into its crystal structure. Analysis of apatite volatile contents can be related to parental magma compositions through the application of pressure and temperature-dependent exchange reactions (Piccoli and Candela, 1994). Once included within phenocrysts, apatite inclusions are isolated from the melt and preserve a temporal record of magmatic volatile contents in the build-up to eruption. In this work, we measured the volatile compositions of apatite inclusions, apatite microphenocrysts and pyroxene-hosted melt inclusions from the Astroni 1 eruption of Campi Flegrei, Italy (Stock et al. 2016). These data are coupled with magmatic differentiation models (Gualda et al., 2012), experimental volatile solubility data (Webster et al., 2014) and thermodynamic models of apatite compositional variations (Piccoli and Candela, 1994) to decipher pre-eruptive magmatic processes. We find that apatite halogen/OH ratios decreased through magmatic differentiation, while melt inclusion F and Cl concentrations increased. Melt inclusion H_2O contents are constant at $\sim$2.5 wt%. These data are best explained by volatile-undersaturated differentiation over most of the crystallisation history of the Astroni 1 melt, with melt inclusion H_2O contents reset at shallow levels during ascent. Given the high diffusivity of volatiles in apatite (Brenan, 1993), the preservation of volatile-undersaturated melt compositions in microphenocrysts suggests that saturation was only achieved 10 – 103 days before eruption. We suggest that late-stage transition into a volatile-saturated state caused an increase in magma chamber overpressure, which ultimately triggered the Astroni 1 eruption. This has major implications for monitoring of Campi Flegrei and other similar volcanic systems.
Piccoli and Candela, 1994. Am. J. of Sc., 294, 92-135. Stock et al., 2016, Nat. Geosci. Gualda et al., 2012. J. Pet., 53, 875-890. Webster et al., 2014. J. Pet., 55, 2217-2248. Brenan, 1993. Chem. Geol., 110, 195-210.