ABSTRACT

Understanding the processes that trigger explosive eruptions in densely populated areas is important for volcanic hazard assessment. Located 30 km from the city of Rome, Colli Albani is a caldera complex that is currently experiencing seismic and degassing activity, and intermittent uplifts possibly related to magmatic intrusions. This ultrapotassic volcano has produced a series of large eruptions between 600 and 355 ka (up to 63 km^3 dense rock equivalent per eruption) creating pyroclastic flows extending up to 33 km from the eruptive centre (Giordano & CARG team, 2010). These ignimbrites are alkaline and mafic in composition, which is rarely observed for such explosive events, as the rheological properties of mafic melts typically favor effusive eruptions. The cause of this unusual explosivity is thought to be related to magma-CO_2 interaction from shallow carbonates at a depth of 2-7 km (Freda et al. 1997, 2011; Iacono-Marziano et al., 2007; Bianchi et al., 2008).

However, we suggest that the role of CO_2 is from melting of deep-seated carbonates combined with a Cr-rich mantle source as opposed to shallow carbonate assimilation alone. Clinopyroxene hosted melt inclusions are found to have CO_2 up to 3.5 wt. % and H_2O up to 3.9 wt. %. Studies of CO_2 solubility indicate that this high CO_2 content can only be soluble at depths extending past what is thought to be the present-day magma chamber (Bianchi et al., 2008; Moussallam et al., 2015). We use thermo-barometry, informed by machine learning, to determine crystallization conditions of the clinopyroxene phenocrysts to find pressures and temperatures extending up to 16 kbar and 1250 °C. These high pressure clinopyroxenes have high magnesium numbers (0.81 to 0.93) and high CaO content (24.31-25.40 wt. %). This deep material is further separated into two groups: one with low Cr and moderate temperature (1100 °C) and one with high Cr and the highest temperatures (up to 1250 °C). We suggest these two groups correspond to magmatism associated with melting of a dolomitic slab and melt derived from the asthenosphere. We also found low pressure clinopyroxenes which are relatively silica poor, FeO rich, and maintain the high CaO component. We suggest these clinopyroxenes represent the shallow magma chamber which is mobilized only due to the injection of the deep magma through to the surface. We propose the possible driving force of this eruption to be volatile expansion from depth resulting in a 5-9-fold increase in volume, accelerating this deep magma through the crust to its final explosive end.

Keywords: Alkaline magmatism – CO_2 – Carbonate assimilation - Thermo-barometry – Italian volcanism