Geophysical Research Abstracts
Vol. 20, EGU2018-15911, 2018
EGU General Assembly 2018

3D textural and geochemical investigations to explore magma chamber and conduit dynamics of plinian eruptions: a Somma-Vesuvius volcano (Italy) case study

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3D textural (via X-ray microtomography) and geochemical (major-volatile elements and Sr-Nd isotopic ratios) investigations, together with thermodynamic simulations, can allow to reconstruct the evolution of magmatic variables governing magma chamber and volcanic conduit processes. Therefore these variables, together with external environmental factors (e.g. influx of external water or wall rock interaction, width of the conduit etc.), exert a major control on the eruptive behavior. In particular, the eruptive dynamic of active volcanic systems developed within a carbonate substrate (e.g. Somma-Vesuvius, Colli Albani, Merapi, Popocatepetl) can be strongly affected by magma-limestone interaction.

In this case study we have examined eruptive products of the Pomici di Base plinian eruption, the oldest (22 ka) and largest explosive event of the Somma-Vesuvius. This eruption was characterized by a plinian (sustained-column) phase during which a 4.4 km3 fallout deposit (maximum column height: 16-17 km; MDR: 2-2.5x107 kg/s) was emplaced, ranging upwards from trachytic pumice ($\sim$25% of volume) to latitic-shoshonitic scoriae ($\sim$75% of volume).

Carbonate Assimilation ($\sim$2.5%) combined to Fractional Crystallization (AFC) processes in a chemically, thermally (from 900 to 1050 °C) and rheologically (log η from 2.91 to 1.89 Pa s) zoned magma chamber, located at a depth of 4-6 km, are required to explain the observed geochemical and isotopic variations. Thermodynamic simulations show the existence of a critical crystallization temperature ($\sim$930 °C), at which chemical and physical magma properties have changed abruptly promoting magma eruptability and acting as eruption trigger mechanism.

Our 3D textural features suggest that microlite-free trachytic magma erupted at beginning of the eruption was affected by rapid decompression (8-9 MPa/s) under closed-system degassing regime. Conversely the hotter microlite-rich latitic-shoshonitic melts suffered limestone assimilation during magma ascent, under open degassing conditions, through the carbonatic bedrock (skarn recycling) generating rapid CO_2 nucleation pulses with deep impact on eruption intensity.

We conclude that limestone assimilation can hence be a syn-eruptive process, able to trigger further volatile vesiculation events, particularly crucial when hot mafic magmas are involved.