Melt inclusions track changes in chemistry and oxidation state of Etnean magmas

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Mount Etna (Italy) is a stratovolcano, located near the convergent boundary between African and European plates. Since its appearance, it was characterized by continuous variability of eruptive style and magma composition, though more subtle. Currently, its volcanic activity consists of effusive and explosive eruptions marked by high gas fluxes.

Olivine hosted melt inclusions (MIs), belonging to products of the last 15 ky, were analysed for their chemical composition, volatiles contents and Fe speciation, in order to interpret the chemical variability and to evaluate the oxidation state of Etnean magmas and its eventual evolution.

Olivine phenocrysts were selected from the most primitive Fall Stratified (FS) eruption of picritic composition (Fo_{91}), from the oldest Mt. Spagnolo and from more recent eruptions: 2002-2003, 2006, 2008-2009, and 2013; the MIs of some of these eruptions (Mt Spagnolo, 2008-2009 and 2013) are here investigated for the first time.

The variability of the major elements contents in the MIs designates a continuous differentiation trend, marked by the decrease of MgO and CaO/Al_2O_3 ratio and the increase of alkalis. The volatiles content in etnean magmas is extremely variable. The highest H_2O (5-6 wt.%) and CO_2 (~0.5 wt.%) contents are found in FS magma entrapped at depth of 16-18 km (below crater level). S content achieves 4150 ppm in the older Mt. Spagnolo inclusions, completely H_2O and CO_2–free.

$Fe^{3+}/\Sigma Fe$ ratios obtained from XANES spectra for some melt inclusions, generally decrease from the most primitive and volatile-rich FS to the most evolved and degassed melts, suggesting changing in the oxidation state of etnean magmas. Petrological arguments coupled to modelling of fractional crystallization and degassing processes concur to suggest that the magmas of Mt. Spagnolo and of the recent eruptions may be produced by differentiation from the most oxidized and hydrous pristine FS magma along highly variable P-T paths, occasionally accompanied by mixing processes.