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Chlorine as a geobarometer tool: Application to the large explosive eruptions of Vesuvius

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One of the current stakes in modern volcanology is the definition of magma storage conditions which has direct implications on the eruptive style and thus on the associated risks and the management of likely related crisis. In alkaline differentiated magmas, chlorine (Cl), contrary to H_2O, occurs as a minor volatile species but may be used as a geobarometer.
Numerous experimental studies on Cl solubility have highlighted its saturation conditions in alkaline silicate melts. The NaCl-H_2O system is characterized by immiscibility under wide ranges of pressure, temperature and NaCl content (< 200 MPa, < 1000°C). The addition of the silicate melt to the system does not rule out this property. These P-T conditions are very common for alkaline magmas evolving in shallow reservoirs, and they strongly affect the evolution of sin-eruptive magmatic melts and fluids. In H_2O-bearing systems, the Cl concentration in the exsolved H_2O vapour phase may increase with that of Cl in the silicate melt. Yet this system becomes strongly non-Henryan at high Cl concentration, depending on P-T conditions: the exsolved fluid phase unmixes to form a low-density, Cl-poor and H_2O -rich vapour phase, and a dense hypersaline brine. In such a subcritical domain, as the composition of both vapour phase and brine is fixed, also the Cl concentration in the silicate melt is invariant, as expected from the Gibb's phase rule. The Cl buffer value will depend on the silicate melt composition, being higher in alkali-rich melts. The achievement of the Cl buffer value is so explained by the equilibrium of the silicate melt with a two-phase fluid in the reservoir. As this equilibrium is generally inherited from conditions established in the reservoir rather than during magma ascent, Cl buffering effect can be evidenced through the analysis of the residual glass.
Here we applied systematically this methodology to the large explosive eruptions of Monte Somma-Vesuvius: We have analysed the products of 13 explosive eruptions of Monte Somma-Vesuvius, including four Plinian (Pomici di Base, Mercato, Avellino, Pompeii), five sub-Plinian (Verdoline, AP1, AP2, Pollena, 1631 AD) and four violent strombolian to ash emission events (AP3, 1822, 1906, 1944). We have focussed our research on the earliest emitted, most evolved products of each eruption, likely representing the shallower, H_2O-saturated portion of the reservoir. We highlighted two magma ponding zones, at ∼170-200 MPa and ∼105-115 MPa. We have also estimated maximum pre-eruptive H_2O content for the different magma compositions, varying between 3.5 and 7 wt%. The results, in large agreement with literature, are very promising. The Cl geobarometer may help scientists to define the reservoir dynamics through time and provide strong constraints on pre-eruptive conditions, of outmost importance for the interpretation of the monitoring data and the identification of precursory signals.