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Trace Element Mobility During Mixing of Magmas as a Proxy for Determination of Volcanic Eruption Time-Scales

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Understanding the timing of volcanic eruptions is a central issue in volcanological research. To date, no one method appears capable of providing unequivocal information on the imminence of a volcanic explosion. One volcanic area in which the knowledge of eruption timescales is crucial is the Phlegrean Fields region home to more than 1.5 million people (Orsi et al., 1996). Recent magmatism (ca. 60ka BP to 1538 AD) has generated mostly explosive events; in the last 15 kyrs ca. 70 eruptions have been recognized (e.g. Orsi et al., 1996). Understanding the mechanisms triggering such eruptions is crucial, since the Phlegrean Fields caldera is considered as an active volcanic system that is thus likely to erupt in the future.

To this aim, the variation of chemical element compositions in two pyroclastic sequences (Astroni 6 and Averno 2, Phlegrean Fields, Italy) is studied. Both sequences are compositionally zoned indicating a variability of melt compositions in the magma chamber prior to eruption. A clear dichotomy between the behavior of major vs. trace elements is also observed in both sequences, with major elements displaying nearly linear inter-elemental trends and trace elements showing a variable scattered behavior. Together with previous petrological investigations (e.g. Civetta et al., 1997) these observations are consistent with the hypothesis that magma mixing processes played a key role in the evolution of these two magmatic systems.

Recently it has been suggested that mixing processes in igneous systems may strongly influence the mobility of trace elements inducing a ‘diffusive fractionation’ phenomenon, whose extent depends on the mixing time-scale (Perugini et al., 2006; 2008). Here we merge information from 1) detailed geochemical studies of natural samples from Phlegrean Fields, 2) numerical simulations of magma mixing, and 3) magma mixing experiments (using as end-members natural compositions from Phlegrean Fields; e.g. De Campos et al., 2004) to derive a relationship relating the degree of ‘diffusive fractionation’ to the mixing time-scales.

Application of the ‘diffusive fractionation’ model to the two studied pyroclastic sequences allowed us to apply the relationship derived by numerical simulations and experiments to estimate the mixing time-scales for these two magmatic systems. Results indicate that mixing processes in Astroni 6 and Averno 2 systems lasted for approximately two and nine days, respectively, prior to eruption.

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