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Element distribution between magmatic fluid and rhyolitic silicate melt, as determined from natural samples from the Kos Plateau Tuff (Greece)

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Determining the composition of natural fluids exsolved from magmas at depth is crucial for our understanding of volcanic degassing processes and the formation of magmatic-hydrothermal ore deposits. Here, we analyzed (a) co-existing melt and vapor-like fluid inclusions, (b) co-existing brine and vapor-like inclusions, and (c) pure end-member assemblages, using LA-ICP-MS. Inclusions hosted in quartz were most suitable for analysis due to quartz being a physically strong container and a relatively pure mineral. To evaluate effects of diffusion through the crystal lattice, inclusions hosted in feldspar were also analyzed. In contrast to previous studies targeting the magmatic-hydrothermal transition (e.g. Zhang & Audétat, 2018), the silicate melt inclusions analyzed here were glassy and did not require re-homogenization.

Silicate melt inclusions from rhyolitic pumice samples from the Kos Plateau Tuff (e.g. Allen et al., 1999) show very little variability in major and trace element composition both within single assemblages and across different assemblages. In contrast, those from in granitic clasts that formed co-genetically with the KPT pumices (e.g. Bachman, 2010) display more heterogeneous compositions even within assemblages and a late-stage fractionation trend with extreme enrichment of some incompatible elements such as Cs, B, W and As, suggesting entrapment at crystallinities of up to > 99 %.

Fluid inclusions were observed only in co-genetic granites. According to microthermometric studies, these fluids were entrapped at near-magmatic temperatures (total homogenization of brine inclusions at > 500 °C). Brines have a salinity of ca. 35-50 wt% NaClequiv and contain 1-4 solid crystals. Vapor-like inclusions co-existing with silicate melt inclusions (vapor-1) are denser (ca. 20-40 vol% liquid), tend to be healed better, and display a larger range of salinities (ca. 3-15 wt% NaClequiv) than those co-existing with brine inclusions (vapor-2). CO_2 was detected by Raman spectroscopy in some vapor-like inclusion assemblages, but never in those coexisting with silicate melt inclusions, making it unlikely that vapor-2 resulted directly from boiling of vapor-1.

Analysis of co-existing silicate melt and intermediate-density fluid inclusions revealed a preference of the elements Cu, As, and Pb for the vapor phase, while the elements Rb, Cs, Na, and K preferred the melt phase. The elements B, Mn, Fe, and W scatter around unity. All other elements were below detection limit (in the vapor phase). Between a low-density vapor and a brine, most elements including Cu prefer the brine and only B clearly partitions into the vapor phase. The elements Sn, As, and Zn scatter around unity. These results are assumed to be representative for very evolved, subduction-zone-related magmatic suites without high F concentrations.