Novel approach for olivine-hosted melt inclusion corrections and its application to northern Japan tephras.

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Olivine-hosted melt inclusions (MIs) are widely used as a tool to study the early stages of magmatic evolution. There are a series of processes after MI trapping that affect MI composition, including post-entrapment crystallization (PEC) of the host mineral at the MI boundaries, exsolution of volatile phases into a "shrinkage bubble" and diffusive exchange between the MI and his host. Classical correction schemes applied to olivine-hosted MIs include PEC correction through addition of olivine back to the melt until it reaches equilibrium with the host composition and "Fe-loss" correction for Fe-Mg diffusive exchange as described by Danyushevsky et al. (2000). These two corrections rely on the assumption that the original host composition is preserved. Usually, studies focus on high forsterite melt inclusion (>Fo80), where the degree of correction is small and the olivine host composition is assumed to be preserved.

In this study we develop a novel MI correction scheme that is applicable to more evolved (< Fo80) melt inclusions where the original host crystal composition has not been preserved. The new scheme allows correction of MI compositions from antecrystic hosts with long and varied temperature histories. The correction relies on fitting a set of MIs compositions to modelled liquid lines of descent (LLD) through fractional crystallization (FC). A Matlab® script iterates FC simulations using alphaMELTS (Asimow and Ghiorso, 1998; Ghiorso and Sack, 1995) starting from the most primitive MI composition of a set. A grid of initial conditions with variable P, H_2O, fO_2, olivine addition and MgO/FeO_t of the first MI are selected to simulate the possible magmatic conditions and the effects of PEC and Fe-Mg exchange on the first MI.

After the generation of the FC simulations, each MI is fitted to the modelled LLDs by addition of olivine to the MI composition. The best fit for each MI is obtained by minimizing the compositional distance between the corrected MI and the LLD. We use the definition of the Aitchison distance for a compositional space geometry (Aitchison, 1986) to quantitively compare similarity between two compositions. The combination of the minimum Aitchison distance of the set of melt inclusion to each LLD is a measure of "good of fitness" of each FC model to the corrected set of MI compositions. Statistical analysis of the models shows that the best fit results for basic MI compositions converges on a particular mineral proportion of the FC path (olivine:pyroxene:plagioclase).

Application of this methodology to MI sets provides estimations of original compositions and magmatic conditions during MI entrapment. Two sets of MIs hosted in olivine antecrysts (Fo76-78) from basaltic tephras from Hakkoda and Akita-Komagatake volcanoes were processed using this methodology. Hakkoda MIs are enriched in Fe compared to whole rock trends, caused by Fe-gain through diffusive equilibration during storage, whereas most MIs in the Akita sample loss suffered of Fe during storage. Using the new correction methodology, we estimate that crystallization of the host crystals in Hakkoda occurred at <1.5 kb and c. 1.5 H_2O wt%, whereas in Akita it occurred at <1.0 kb and c. 1.0 H_2O wt%.

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