On the relationship between melt inclusion CO_2 and magma storage depths

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The CO_2 content of olivine-hosted melt inclusions contains information about the pressure of inclusion entrapment and magma storage depths in basaltic systems. Post-entrapment processes such as crystallisation on the inclusion walls and bubble growth can modify the CO_2 concentration within the melt and methods have previously been developed to correct for these effects. Even when such corrections are applied, barometers based on CO_2-saturation return significantly lower pressures of entrapment than barometers based on major–element exchange between crystals and melt. This phenomenon is clearly demonstrated in the eruptive products of the AD 1783 Laki event in Iceland which displays remarkable barometric inconsistency.

More generally, analysis of a global dataset of melt inclusion compositions from low-H_2O settings, such as mid-ocean ridges and ocean islands, indicates that corrected melt inclusion CO_2 contents do not provide a simple indicator of magma storage depths. The distribution of recovered CO_2 saturation pressures from the global dataset displays surprising similarities across settings where magma stroage conditions vary widely. The probability densities of these distributions are flat at saturation pressures of <200 MPa and <20% of inclusions have saturation pressures >200 MPa. These features of the global distribution indicate that decrepitation of melt inclusions plays a key role in controlling the observed CO_2 content of olivine-hosted melt inclusions.

A coupled petrological-mechanical model of the evolution of olivine-hosted melt inclusions after their entrapment was developed in order to explore this problem. The major element and CO_2 content of the silicate melt in the inclusion, the host olivine and bubbles were included in the calculations. The model initially included only reversible processes and the pressure-temperature-composition path of the inclusions were predicted as a function of imposed P-T paths of the host during post-entrapment storage and transport of the host crystal. When decrepitation is included in the models can crucial observations from the melt inclusion dataset be matched. The model results indicate that rare inclusions with substantial pre-eruptive cooling intervals may be able to avoid CO_2 loss by decrepitation. These inclusions can provide accurate barometric estimates, but can only be identified by processing large numbers of inclusions.