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The Poisoned Chalice? Understanding carbon in olivine-hosted melt inclusions

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The solubility of CO_2 in basaltic liquids is dependent on pressure. The CO_2 content of olivine-hosted melt inclusions therefore provides a potential source of information about the depths of magma storage. Such petrological constraints on magmatic histories provide context for the interpretation of geophysical volcano monitoring data. However, when multiple petrological barometers are available for the magmatic suites, pressure estimates from melt inclusion CO_2 contents appear to be systematically low, even when saturation has occurred. In this contribution I will explore the role of the post-entrapment pressure-temperature-time (P-T-t) path of the host crystal in controlling the relationship between observed melt inclusion CO_2 contents and entrapment pressures.

A global compilation of 2878 melt inclusions from mafic volcanics of mid-ocean ridges, ocean islands and continental rift zones reveals some unexpected features. First, the distribution of estimated saturation pressures is not strongly dependent on the methods of correction of measured inclusion compositions for post-entrapment crystallisation and bubble growth. Second, the different tectono-magmatic settings show similar distributions of estimated saturation pressures. Third, 80% of the recovered saturation pressures are $<$100 MPa and much more than half correspond to pressures that are lower than those of the shallowest reservoir in the system as constrained by geophysical observations. Finally, in all settings, 5-10% of the inclusions record saturation pressures $>$200 MPa, with an upper limit at $\sim$500 MPa.

A model was developed of the evolution of the pressure and distribution of CO_2 inside inclusions as their olivine hosts travel through an imposed P-T-t history. Model results indicate that the dominance of low saturation pressures in the melt inclusions and the systematic difference between these pressures and the independent estimates of magma storage depths are likely to be caused by decrepitation: previous experimental studies have found that the maximum pressure difference that can be maintained between large fluid inclusions and the external melt is $\sim$200-300 MPa.

A fraction of the inclusions record higher apparent pressures of saturation. These bubble-bearing inclusions may have experienced significant post-entrapment cooling and crystallisation, which acts to reduce pressure in olivine-hosted inclusions. Such inclusions provide the most useful barometric constraints for magmatic histories.