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Carbon in Plume magmas: Insights from high-PT homogenisation of olivine-hosted melt inclusions

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Earth's interior carbon cycle is characterised by input of surface carbon through subduction of sediment-covered tectonic plates, and by outgassing of mantle-derived magma formed at mid ocean spreading ridges, mantle plume- and subduction zone volcanoes. Constraints on the carbon budget of Earth's mantle are based in part on measurements of the carbon content of melt inclusions (MI) in early-formed phenocrysts in mantle-derived magmas. Such measurements are complicated due to significant changes that occur inside a melt inclusion between formation at depth and eruption, including the exsolution of CO_2-bearing gas bubbles and the formation of crystals.

"Traditional" partial homogenisation experiments performed by heating the melt inclusions at 1 atmosphere indicate that, up to 90% of all CO_2 in a MI can be transferred to a shrinkage bubble, and that empirical CO_2 back-calculation procedures introduce up to 50% uncertainties. Based on this "traditional" procedure the maximum CO_2 contents in plume-related melts range between 600-4000 ppm in MI glass, increasing up to 1-2.5 wt.% if the empirical back-calculation method is used. In this study we present pioneer results of high pressure and high temperature (8-12 kbar - 1450°C) experiments in which we achieved complete homogenization of melt inclusions in high forsterite olivines from plume related magmatism at Hawaii, Reunion, Azores, and the Canary and Austral Islands and, covering a wide compositional range. Maximum CO_2 concentrations in the completely homogenized MI range between 3000 and 6300 ppm depending on the plume location. Variations in CO_2 concentrations in conjunction with variations in abundances of other volatiles and trace elements, and magma types will be discussed.

A comparison between MI water contents after "traditional" 1-atm homogenisation experiments and in completely homogenized MI after high-PT experiments indicates a significantly unaccounted water reservoir in shrinkage bubbles. Our data show that 30 to 80 % of water in the initially trapped melt has moved to the shrinkage bubble together with CO_2. The presence of such proportions of H_2O in shrinkage bubbles can lead to a significant increase in the error and CO_2 over-estimations using the empirical method.