X-ray microtomography-based reconstruction of total CO_2 in olivine-hosted melt inclusions

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The global system of mid-ocean ridges represents a major locus of mantle CO_2 outgassing [1]. Despite its importance to the global C budget, quantifying the CO_2 flux from the mantle is hindered by magma degassing. The solubility of CO_2 in silicate melts is strongly pressure sensitive, leading to significant CO_2 loss as magmas decompress and degas during ascent. Olivine-hosted melt inclusions (MIs) are an important source of information on the pre-eruptive CO_2 contents of ocean floor lavas. The strength of the host crystal protects MIs from the decompression experienced by the entraining magma. However, a major uncertainty associated with using melt inclusions to determine the flux of CO_2 from the oceanic upper mantle is the common occurrence of CO_2-rich vapor bubbles (VB). In these instances, reconstructing total CO_2 requires precise determination of the mass in the included glass and coexisting VB [2]. The concentration of CO_2 in the included glass can be measured using secondary ion mass spectrometry (SIMS), and the density of CO_2 in the VB determined by Raman spectroscopy. To date, the volumes of included glass and coexisting VBs have relied on 2-D petrographic measurements mapped onto simplied 3-D geometries. We used x-ray microtomography to obtain precise determinations of these volumes. Results for olivine-hosted MIs from pillow lavas of the late Pleistocene subglacial Miðfell eruption in south Iceland demonstrate that the 2-D petrographic approach systematically overestimates the MI volume and, thereby, underestimates total CO_2. The concentration of CO_2 measured in the glass portion of the MIs by SIMS ranges from 64 to 1160 μg/g. When present, vapor bubbles typically represent ~2.5 % of the volume of the inclusion, with CO_2 densities ranging from 0.06 to 0.25 g/cm^3. Total CO_2 concentrations calculated for bubble-bearing MI using 3-D tomographic volumes (1340-4550 μg/g) are typically ~30 % higher than those determined using 2-D petrographic volumes (1010-3150 μg/g).

[1] Chavrit et al. (2014) *EPSL* **387**, 229-239. [2] Moore et al. (2015) *Am Min* **100**, 806-823.