Constraints from homogenized melt inclusions on volcanic degassing paths and mantle CO_2

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A major challenge in the study of volatiles in arc magmas is the determination of parental concentrations of CO_2, important to whole-Earth carbon cycle models. Unlike mid-ocean ridge or ocean island basalts, there are no simple non-volatile proxies for arc magmatic CO_2 concentrations. Due to its low solubility, CO_2 may be lost from the magma early in its evolution. Even though olivine-hosted melt inclusions (MIs) may preserve undegassed compositions, they often exsolve a vapor bubble rich in CO_2 during cooling and decompression. Here we combine new data on experimentally homogenized melt inclusions with inferences from volcanic gases to reconstruct arc magmatic CO_2 degassing systematics.

Piston cylinder experiments were conducted at 500-800 MPa and 50-100°C above entrapment temperatures under hydrous conditions (4-7 wt.% H_2O) with run durations of 10-120 minutes [1]. This technique leads to bubble resorption of many MIs simultaneously. Homogenized MIs (n=23) from the basaltic 1974 eruption of Fuego form an exceptionally coherent CO_2-S degassing path, elevated in CO_2 relative to untreated inclusions by up to a factor of 6. The degassing path demonstrates that sulfur (2800 ppm initial) may be lost to vapor at high pressure (> 5kb), leading to lower CO_2/S vapor than predicted by most thermodynamically based models (at the same fO_2 as Fuego, ~NNO). Maximum CO_2 concentrations are 4000 ppm, giving a molar CO_2/S ratio of ~1, consistent with the low CO_2/S ratios inferred for Fuego from regional systematics in non-volatile element ratios (e.g., Ba/La)[2]. Assuming a MORB CO_2/Nb of 607 [3] and 1.5 ppm Nb in Fuego basalt, only ~ 20% of the Fugeo CO_2 is mantle-derived. This is a maximum given that higher CO_2 contents in Fuego are possible, and so >80% of the CO_2 at Fuego is from subducted (or crustal) sources. This work is an example of the enormous potential for using populations of homogenized melt inclusions to improve our understanding of both the pressure-composition relationships of magmatic gases and the sources of CO_2 in arc volcanoes.

[1] Rasmussen and Plank, *AGU*, 2017.
[2] Aiuppa et al., *Scientific Reports*, in press, 2019
[3] LeVoyer et al., *Nature Comm*., 2017