Volatiles in melt inclusions and apatite from Erebus phonolite

WEIRAN LI[1*], FIDEL COSTA[1,2], CLIVE OPPENHEIMER[3]

[1] Earth Observatory of Singapore, Nanyang Technological University (*correspondence: weiran.li@ntu.edu.sg)
[2] Asian School of Environment, Nanyang Technological University
[3] Department of Geography, University of Cambridge

Magmatic volatiles such as CO_2 and H_2O play a major role in magmatic processes and eruptive behaviour. Abundances of H_2O in the melt can be determined by volatile measurements on apatite, combined with thermodynamic analyses of F-Cl-OH partitioning between apatite and melt [1]. A similar method should be possible to assess melt CO_2 contents but studies of the concentration of CO_2 in apatite and its partition behaviour are few. Here we provide new measurements (using SIMS) and thermodynamic analysis of CO_2, H_2O, F, Cl and S concentrations in co-existing apatite and phonolitic glass inclusions, hosted by anorthoclase megacrystals of lava bomb samples from Mt. Erebus (Antarctica; [2]). We find that the melt inclusions (MIs) contain similar volatile compositions: ~0.16 wt.% H_2O, ~90 ppm CO_2, ~2100 ppm F, ~1400 ppm Cl, ~350 ppm S. The coexisting fluorapatite crystals have a limited range of F ≈ 3.5 wt.%, Cl ≈ 0.13 wt.%, H_2O ≈ 0.06 wt.%, and S ≤ 5 ppm, but a wide variation in CO_2 from ≈ 120 to 1600 ppm. Apatite-melt inclusion pairs indicate exchange coefficient (K_D) for Cl-F of ~0.11, equivalent to that calculated from [1] at 950–1000 ºC. Using the apatite hygrometer model of [1], the melt should contain >0.5 wt.% H_2O. This is higher than that measured in MIs but can be explained by diffusive H_2O loss. The calculated values of the Nernst partition coefficient (D) for CO_2 are ~1.6–2.8, which are much higher than those (of ~0.11–0.12) determined by [3] at 1 GPa and 1250 ºC for trachytic melts and F-rich apatite. The calculated value of exchange coefficient K_D for H_2O-CO_2 (on the basis of wt.%) is ~0.04 (±0.02), ~10 times lower than that determined at 1250 ºC by [3]. This discrepancy can be explained by a temperature difference of ~300 ºC, and is comparable to the difference in K_D for OH-F between 950 and 1250 ºC [1]. More experimental studies on apatite-melt CO_2 partitioning are needed to improve estimates of melt CO_2 budgets from CO_2 in apatite.

[1] Li & Costa (2020) *GCA* **269**, 203-222. [2] Moussallam *et al*. (2015) *EPSL* **413**, 1-12. [3] Riker *et al*. (2018) *Am Mineral* **103**, 260-270.