Water in clinopyroxene phenocrysts: faithful recorders of magmatic water contents

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Water is critical to the origin and evolution of magmas, but limited data exist on the concentrations of water dissolved in pre-eruptive magmas, derived largely from rare olivine-hosted melt inclusions. Here we explore a new approach to calculating the H_2O contents of magmas, based on direct measurement of H_2O in clinopyroxene (cpx) phenocrysts. We hand-picked cpx from 4 ash/lapilli samples for which H_2O contents have already been measured in melt inclusions: 1723 eruption of Irazu volcano (C. Rica) [1], ~ 1000 AD ET3 tephra of Arenal volcano (C. Rica) [2], 1867 eruption of Cerro Negro volcano (Nicaragua) [3], and 1982-3 eruption of Galunggung (Java) [4-5]. H_2O contents were measured by SIMS ion microprobe, with detection limits < 10 ppm H_2O, and precision of ~ 10% at the 100's ppm level.

A decrease in H_2O is apparent in some cpx rims, due to growth zoning and/or diffusive loss of H within a degassing magma. Concentrations of H_2O in cpx interiors, however, correlate with tetrahedal Al, in accord with recent experimental work [6,7]. Using the Al(IV)-dependent partitioning relationship in [7], we calculate H_2O in the liquid in equilibrium with the cpx. In all four samples, the maximum, the range, and the peak in the mode of the cpx-calculated magmatic H_2O contents coincides closely with those measured in the olivine-hosted melt inclusion population, confirming up to 6.5, 4.3, 3.4, and 0.45 wt% H_2O in Cerro Negro, Arenal, Irazu and Galunggung pre-eruptive magma, respectively. These water contents correlate with Sr/Nd in the cpx (measured by laser-ablation ICP-MS) for the Central American volcanoes, consistent with both H_2O and Sr/Nd as recognized tracers of fluid from the subduction zone. The ability of cpx phenocrysts to record H_2O, trace element ratios, as well as P and T (through thermobarometery), makes them a valuable new tool in the study of magmatic volatiles, particularly for tephra deposits that commonly contain cpx but not olivine-hosted melt inclusions.

References

[1] Benjamin et al., AGU Abstr. 2004. [2] Wade et al., JVGR, in press. [3] Roggensack, EPSL, 2001. [4] Kelley et al., AGU Abstr, 2004. [5] Sisson & Bronto, Nature, 1998. [6] Aubaud, et al., GRL, 2004 [7] Hauri et al., EPSL, in press.