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The quench control of water estimates in convergent margin magmas

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ABSTRACT

Here we present a study on the quenchability of hydrous mafic melts. We show via hydrothermal experiments that the ability to quench a mafic hydrous melt to a homogeneous glass at cooling rates relevant to natural samples has a limit of no more than 9 ± 1 wt% of dissolved H_2O in the melt. We performed supra-liquidus experiments on a mafic starting composition at 1–1.5 GPa spanning H_2O-undersaturated to H_2O-saturated conditions (from ~1 to ~21 wt%). After dissolving H_2O and equilibrating, the hydrous mafic melt experiments were quenched. Quenching rates of 20 to 90 K/s at the glass transition temperature were achieved, and some experiments were allowed to decompress from thermal contraction while others were held at an isobaric condition during quench. We found that quenching of a hydrous melt to a homogeneous glass at quench rates comparable to natural conditions is possible at water contents up to 6 wt%. Melts containing 6–9 wt% of H_2O are partially quenched to a glass, and always contain significant fractions of quench crystals and glass alteration/devitrification products. Experiments with water contents greater than 9 wt% have no optically clear glass after quench and result in fine-grained mixtures of alteration/devitrification products (minerals and amorphous materials). Our limit of 9 ± 1 wt% agrees well with the maximum of dissolved H_2O contents found in natural glassy melt inclusions (8.5 wt% H_2O). Other techniques for estimating pre-eruptive dissolved H_2O content using petrologic and geochemical modeling have been used to argue that some arc magmas are as hydrous as 16 wt% H_2O. Thus, our results raise the question of whether the observed record of glassy melt inclusions has an upper limit that is partially controlled by the quenching process. This potentially leads to underestimating the maximum amount of H_2O recycled at arcs when results from glassy melt inclusions are predominantly used to estimate water fluxes from the mantle.

Keywords: Mafic glassy melt inclusions, hydrous mafic glass quenchability, arc volatile budget, magmatic water; Applications of Fluid, Mineral, and Melt Inclusions