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The partitioning of H_2O between plagioclase and dacite melts at crustal conditions: Experimental constraints

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The quantification of pre-eruptive magmatic H_2O is critical due to the significance of this variable in volcanic processes and associated hazards. We present a new hygrometric proxy for dacitic magmas by experimentally determining H_2O partitioning between plagioclase and dacitic melt, a relationship previously unquantified. Plagioclase is ideal for this purpose as it is common in arc magmas, stable over a wide P-T-X range, and has lower H diffusivity than other silicate minerals[1].

We measured H_2O concentrations in plagioclase and coexisting dacitic glass (SIMS) from vapor-saturated experimental runs[2,3]. The starting material of the experiments has a Mount St. Helens dacitic composition (65.2 wt.% SiO_2). The chosen experiments were performed in piston-cylinder apparatuses[2,3] at 900-1000 ºC, 0.4-1.3 GPa. Oxygen fugacity was buffered close to the Re-ReO_2 buffer. Temperature was held above the liquidus for 2 hours before being adjusted to the target run conditions. This methodology induced the crystallization of euhedral and homogeneous plagioclase crystals in equilibrium with dacitic to rhyodacitic melt[2,3], which were large (>50 µm) enough to be analyzed by SIMS.

The results of the first analytical session on experimental runs with 66.5-71.7 wt.% SiO_2 in glass and An_{43-60} show 3.7-5.6 wt.% $H_2O^T_{glass}$ and 94-137 µg/g H_2O_{plag}, resulting in $D^{plag\text{-}glass}_{H2O}$ between 2-3*10^{-3}. We report no discernable correlation of $D^{plag\text{-}glass}_{H2O}$ with experimental temperature, pressure, or FeO^T_{plag}. A negative correlation between $D^{plag\text{-}glass}_{H2O}$ and An# is observed. This is the first report of such correlation as previous studies focused on Na-free systems or used plagioclase seeds of fixed composition. These observations could suggest H incorporation in tetrahedral vacancies, and ongoing work seeks to explore this possibility.

The lack of correlation between $D^{plag\text{-}glass}_{H2O}$ and most intensive variables (T,P) suggests H_2O_{plag} contents could be a useful proxy for magmatic H_2O concentrations. When combined with other methods such as melt inclusion volatile analysis, H quantification in rapidly diffusing phases (e.g., olivine, pyroxene) or plagioclase-melt hygrometry, our method may better constrain pre-eruptive H_2O contents by mitigating post-crystallization/entrapment bias.

[1]Johnson & Rossman (2013), Am Mineral, 98, 1779-1787

[2]Blatter, Sisson & Hankins (2017), Contrib Mineral Petrol, 172, 27

[3]Blatter, Sisson & Hankins (2023), Contrib Mineral Petrol,