Hydrogen concentration in plagioclase as a hygrometer of arc basaltic melts: approaches from melt inclusion analyses and hydrous melting experiments

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The hydrogen in nominally anhydrous minerals (NAMs) can be an indicator of H_2O activity in silicate melts if the partitioning coefficient of hydrogen between NAMs and melts is known. Although plagioclase is one of the most common NAMs in arc basaltic rocks, few studies have been performed to constrain partitioning and solubility of hydrogen in plagiocase.

Here, we determined the partition coefficient of hydrogen between plagioclase and basaltic melt by two approaches. For the first part of this study, plagioclase-hosted melt inclusions in mid-ocean ridge basalt were analyzed. The hydrogen concentration in plagioclase is less than 60 wt. ppm water, and the average H_2O concentration in melt inclusions is 0.3 wt.%. Therefore, the apparent partition coefficient of hydrogen between plagioclase and melt is approximately 0.01 on a molar basis. For the second part of this study, hydrous melting experiments of basaltic magma were performed at 0.35 GPa using an internally-heated pressure vessel. A grain of Ca-rich plagioclase (1 mg) and 10 mg of powdered basaltic glass with 0.8-5.5 wt.% H_2O were sealed in a AuPd alloy capsule, and then kept at near the crystallization temperature of plagioclase as a liquidus phase to attain an equilibrium of hydrogen between plagioclase and melt. Combining the results of these two parts of the study, we formulated two linear equations to correlate the hydrogen concentration in plagioclase and H_2O concentration in basaltic melt. When H_2O in melt is $\leq$1 wt.%,
hydrogen in plagioclase (wt. ppm water) $\approx$ 80 x H_2O in melt (wt.%).
When H_2O in melt is $\geq$ 4 wt.%,
hydrogen in plagioclase (wt. ppm water) $\approx$ 40 x H_2O in melt (wt.%).
Hydrogen concentration in plagioclase lies between two equations when H_2O in melt ranges from 1 to 4 wt.%. In accordance with these two formulations, the partition coefficients of hydrogen between plagioclase and basaltic melt switches from 0.01$\pm$0.005 under H_2O-poor conditions to 0.005$\pm$0.001 under H_2O-rich conditions. Such switches of hydrogen partitioning can be related to change of the atomic site for hydrogen in the crystal structure of plagioclase.

The hydrogen concentration in Ca-rich plagioclase from the 1986 summit eruption of Izu-Oshima volcano, a frontal-arc volcano in Izu arc, shows variation ranging from <50 through 300 wt. ppm H_2O as a result of polybaric degassing (Hamada et al., 2011 *Earth Planet. Sci. Lett.*). Our present study confirms that plagioclase with 300 wt. ppm H_2O can be in equilibrium with melt dissolving about 6 wt.% H_2O, which also confirms presence of H_2O-rich magmas beneath arc volcanoes.