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Experimental constraints on partitioning of hydrogen between plagioclase and basaltic melt

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Introduction: The hydrogen in nominally anhydrous minerals (NAMs) can be an indicator of H_2O activity in silicate melts if the partitioning behavior of hydrogen between NAMs and melts is known. Plagioclase is one of the NAMs and one of the most common minerals in arc basaltic rocks. Therefore, hydrogen in volcanic plagioclase (OH) can be an useful proxy of H_2O in arc basaltic magmas. Here, we report experimental results on the partitioning of hydrogen between Ca-rich plagioclase and basaltic melt. We also apply the OH concentration of plagioclase as hygrometer of melt based on experiments.

Experimental: Hydrous melting experiments of arc basaltic magma were carried out at 350 MPa using an inter-nally-heated pressure vessel installed at Magma Factory, Tokyo Institute of Technology. Starting material was hydrous glass (0.8 wt.%$<H_2O<$5.5 wt.%) of an undifferentiated rock from Miyakejima volcano, a frontal-arc volcano in Izu-arc (MTL rock: 50.5% SiO_2, 18.1% Al_2O_3, 4.9% MgO). A grain of Ca-rich plagioclase (about 1 mg, An_{95}, FeO_t = 0.4 wt.%) and 10 mg of powdered glasses were sealed in $Au_{80}Pd_{20}$ alloy capsule, and then kept at around liquidus temperature. Liquidus phase of MTL rock at 350 MPa is always plagioclase with 0 to 5.5 wt.% H_2O in melt (Ushioda, unpublished data), and therefore, a grain of plagioclase and hydrous melt are nearly in equilibrium. Oxygen fugacity (fO_2) during the melting experiments was not controlled, and the intrinsic fO_2 of the pressure vessel was estimated to be 3 log unit above Ni-NiO buffer. Experiments were quenched after 24-48 hours, long enough to attain equilibrium partitioning of hydrogen between plagioclase and melt. Concentration of H_2O in melt (both molecular H_2O and OH) and concentration of OH in plagioclase was analyzed by infrared spectroscopy.

Results: Experimental results are summarized in Fig. 1. Correlation between total H_2O (molecular H_2O and OH) concentration in melt and OH concentration in plagioclase is non-linear: partition coefficient in molar basis is about 0.01 with low H_2O in melt ($<$ 1 wt.%), while it decreases with increasing H_2O in melt (Fig. 1a). The OH concentration of plagioclase reaches 200-250 wt. ppm H_2O with $>$ 4 wt.% H_2O in melt and saturates. OH in plagioclase linearly correlates with OH in melt (Fig. 1b), which confirms that hydrous species in plagioclase is OH ion as suggested by previous studies.

Application: The OH concentration of Ca-rich plagioclase (about An_{90}) from the 1986 summit eruption of Izu-Oshima volcano, also a frontal-arc volcano in Izu-arc, shows variation ranging from $<$50 wt. ppm H_2O through 300 wt. ppm H_2O as a result of polybaric degassing (Hamada et al., 2011, EPSL). Hamada et al. (2011) claims that pre-eruptive melt dissolves H_2O up to 6 wt.% and that melt undergoes polybaric degassing during ascent and eruption, based on (i) variation of OH in plagioclase, (ii) hydrous melting experiments to crystallize An_{90} plagioclase, and (iii) geophysical observation of the 1986 summit eruption of Izu-Oshima volcano. In consistent with previous studies, this experimental studies demonstrates that plagioclase with $>$250 wt. ppm H_2O can be in equilibrium with melt dissolving $>$4 wt.% H_2O (Fig. 1a). Such high H_2O concentration corresponds to saturated H_2O concentration in melt at 8 to 10-km-deep magma chambers beneath Izu-Oshima volcano (Mikada et al., 1997, PEPI). Plagioclase from the 1986 summit eruption of Izu-Oshima volcano is expected to record polybaric degassing history of H_2O-saturated magma during eruption.

Keywords: Water in nominally anhydrous minerals, plagioclase, arc basasltic magma, hydrous melting experiment

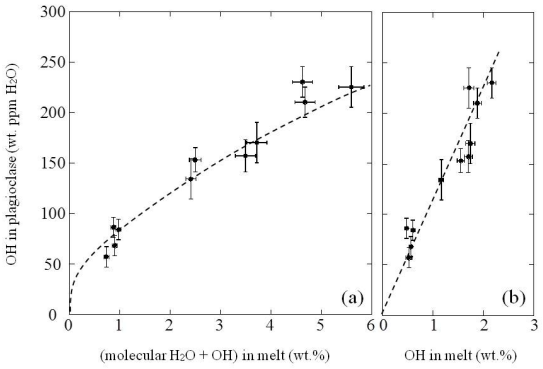

Fig. 1