Water-rich island arc basalt magma inferred from high hydrogen content in anorthite-rich plagioclase

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Anorthite-rich plagioclase (˜An90) is commonly found in island arc basalt on the volcanic front. Its origin has been discussed as crystallization from H_2O-rich (more than 3 wt.%) basalt based on hydrous melting experiments (Sisson and Grove, 1993 Contrib. Mineral. Petrol.; Takagi et al., 2005 Contrib. Mineral. Petrol.; Hamada and Fujii, 2007 Geochemical. J.). However, melt inclusions hosted by anorthite-rich plagioclase dissolve lower H_2O (less than 2 wt.%; Hamada and Fujii, 2007). Hamada and Fujii (2007) explained this contradiction that volatiles might leak from melt inclusions through microcracks in the host phenocrysts after entrapment, which suggests that melt inclusions do not always preserve pre-eruptive volatile content of magma. A question remains as to whether island arc basalt on the volcanic front is H_2O-rich or H_2O-poor.

Several nominally-anhydrous minerals contain trace amount of hydrogen in their crystal structure. Recently, hydrogen in nominally-anhydrous minerals is attracting attention as new tools to quantify the dissolved H_2O in coexisting melt and to monitor the volatile history of magma (Johnson, 2006 Reviews in Mineral. Geochem.). In order to confirm H_2O content at the time of plagioclase crystallization, we analyzed hydrogen in anorthite-rich plagioclase obtained from both the 1986 eruption and the 1987 eruption of Izu-Oshima volcano, using polarized infrared spectra. Izu-Oshima volcano is located on the volcanic front of Izu arc and issues low-K island arc basalt. The 1986 eruption was the major effusive eruption triggered by injection of new magma, while the 1987 eruption was the minor eruption triggered by gas explosion in the conduit.

Plagioclase composition was ranging from An_{80} to An_{94}. Hydrogen content in plagioclase varied from 50 to 300 ppm H_2O, which were higher than hydrogen content of plagioclase in mid-ocean ridge basalt. In general, hydrogen content in plagioclase from the 1986 eruption was higher than that from the 1987 eruption. Variations of plagioclase composition and hydrogen content demonstrate that hydrogen content becomes higher with increasing anorthite content of plagioclase and that hydrogen in plagioclase was lost to some extent by diffusive re-equilibration of hydrogen with ambient degassed melt. Assuming partition coefficient of hydrogen between plagioclase and melt is 0.004 (Johnson 2005, Geochim Cosmochim. Acta), H_2O content in coexisting melt prior to eruption changes widely from nearly dry to ˜6 wt.%. 6 wt.% H_2O in melt, which was estimated for magma from the 1986 eruption, will represent saturated H_2O content in the 8 to 10-km deep magma chamber detected by seismic studies. Assuming such abundant H_2O in melt is consistent with previous melting experiments of hydrous basalt to crystallize anorthite-rich plagioclase. Nearly dry melt will represent degassed melt stored in the lava lake at the summit vent prior to the 1987 eruption.

Analysis of hydrogen in plagioclase phenocrysts suggests that H_2O content of island arc basalt on the volcanic front is H_2O-rich and even saturated with H_2O in the magma chambers prior to eruption. Excess degassing should be common at island arc volcanoes. Therefore, H_2O content of melt which crystallized anorthite-rich plagioclase should be much higher than that of plagioclase-hosted melt inclusions.