

SMP006-08

Room:303

Time:May 25 16:45-17:00

Polybaric degassing of island arc low-K tholeiitic basalt recorded in OH concentrations of Ca-rich plagioclase

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Among hydrous magmas in subduction zones, island arc low-K tholeiitic basalts have been characterized by low H₂O contents, approximately 1 wt.% H₂O, based on melt inclusion analyses and phase equilibria studies. However, melting experiments of hydrous basaltic magmas require higher amounts of H₂O to crystallize Ca-rich plagioclase, which is commonly observed mineral in island arc low-K tholeiitic basalts. The estimated values of H₂O content of low-K tholeiitic magma by different approaches are not consistent. Hydrogen in nominally-anhydrous minerals (NAMs) can be an alternative indicator of dissolved H₂O in magma and degassing history of magma during ascent. Plagioclase is one of the NAMs which accommodates hydrogen up to hundreds of wt. ppm H₂O in it. The speciation of hydrogen in volcanic plagioclase is demonstrated to be structural OH. In this study, we analyzed OH concentration in Ca-rich plagioclase from the summit eruptions of Izu-Oshima volcano, a frontal-arc volcanic in Izu arc and issues island arc tholeiitic basalt, during 1986 and 1987. The OH concentrations of plagioclase were analyzed by polarized infrared spectroscopy, which ranged from 20 to 300 wt. ppm H₂O. Three distributions of OH concentrations, 20-80 wt. ppm H₂O, 100-180 wt. ppm H₂O, and 220-300 wt. ppm H₂O, were found. Variation in the OH concentrations can be explained by the fact that plagioclase had been finally equilibrated with H₂O-saturated melt at three depths beneath the Izu-Oshima volcano; melt under almost atmospheric pressure (1 wt.% H₂O), at the 4-km deep magma chamber (3 wt.% H₂O), and the 8-10-km deep magma chamber (5 wt.% H₂O), respectively. Assuming such polybaric degassing from H₂O-saturated island arc tholeiitic basalts will explain so-called "excess SO₂ degassing", which has been proposed in many arc volcanoes, because SO₂ is preferentially partitioned into degassed H₂O bubbles. We suggest that more H₂O comes from the upper mantle in subduction zones than ever postulated that island arc low-K tholeiitic basalt is H₂O-undersaturated or H₂O-poor.

Keywords: water in nominally-anhydrous mineral, island arc low-K tholeiite, volcanic front, Ca-rich plagioclase