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Polybaric crystallization of H_2O-saturated island arc low-K tholeiite magmas: A case study of the Izu-Oshima volcano

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Introduction: The H_2O concentration of pre-eruptive melts, particularly that of primitive melts, provides information on the *P-T* conditions of their generation, their differentiation pathways, and their potential explosivity of eruptions. Consensus with regard to the H_2O concentration of island arc low-K tholeiitic magmas (melts) remains elusive. We investigated conditions of their crystallization differentiation, particularly the H_2O concentration in melts, using geochemical data of volcanic rocks from Izu-Oshima volcano in the Izu arc, along with the results of hydrous melting experiments.

Geochemistry and petrology of volcanic rocks: We selected 68 aphyric volcanic rocks which exhibit multiply saturated liquid compositions of the Izu-Oshima volcano. Among them, two magma groups are distinguished by the K/Zr ratio, a lower-K subgroup (K/Zr$<$60) and a higher-K subgroup (K/Zr$\geq$60). In this study, we focus on the higher-K subgroup liquids. Two endmember trends, referred to here as a higher-Al/Si trend and a lower-Al/Si trend, have been distinguished in the higher-K subgroup liquids. All the liquids are bracketed by these two endmembers, and thus may be mixtures of the two endmembers or may have been derived under intermediate conditions between those responsible for the two endmembers. An experimental study by Hamada and Fujii (2008, *Contrib. Mineral. Petrol.*) suggests that the higher-Al/Si and lower-Al/Si trends can be reproduced by upper crustal crystallization differentiation of primitive basalt under moderately hydrous ($\sim$3 wt % H_2O) and almost dry conditions, respectively.

Hydrous melting experiments on island arc low-K tholeiite magmas: Island arc low-K tholeiite magma is characterized by presence of Ca-rich plagioclase (An$\geq$90), with Ca-poor rim ($\sim$An75). Hydrous melting experiments on two volcanic rocks from the Izu-Oshima volcano, MA43 and MA44 (MgO$\sim$5 wt %), were conducted at 250 MPa to constrain the origin of Ca-rich plagioclase (Hamada and Fujii 2007, *Geochem. J.*). MA43 and M44 represent less differentiated liquid compositions on the higher-Al/Si and lower-Al/Si trends, respectively. In the melting experiments on MA43, plagioclase crystallized as the liquidus phase at all H_2O content (1$\sim$6 wt % H_2O), and anorthite content of the plagioclase increased from $\sim$An80 under nearly dry conditions to An$\geq$90 with $\geq$3 wt % H_2O in melt. In the melting experiments on MA44, plagioclase crystallized as the liquidus phase under low-H_2O ($\leq$2 wt %) conditions, but augite replaced plagioclase as the liquidus phase with more H_2O in melt. Anorthite content of plagioclase increased from about An70 under nearly dry conditions to An80 with $\sim$4 wt% H_2O in melt. Increases in anorthite content of plagioclase crystallized from the MA44 melt were suppressed compared with plagioclase crystallized from the MA43 melt. In short, Ca-rich plagioclase (An$\geq$90) can be crystallized from melts on the higher-Al/Si trend with $\geq$3 wt % H_2O, but cannot be crystallized from melts on the lower-Al/Si trend with any H_2O. Ca-poor rim ($\sim$An75) cannot be crystallized from melts on the higher-Al/Si trend, but can be crystallized from melts on the lower-Al/Si trend.

Summary: Geochemical variations in the liquids from the Izu-Oshima volcano are bracketed by two endmember trends, namely, the higher-Al/Si and the lower-Al/Si trends. Origins of the higher-Al/Si and the lower-Al/Si trends can be explained by crystallization differentiation under moderately hydrous conditions ($\sim$3 wt% H_2O) and almost dry conditions, respectively. We propose that polybaric crystallization of H_2O-saturated melts, at a depth range between the $\sim$4-km-deep magma chamber ($\sim$3 wt% H_2O) and near surface level (nearly dry) beneath the Izu-Oshima volcano, is a ubiquitous feature of island arc low-K tholeiite magmas.

Keywords: Island arc low-K tholeiite, Volcanic front, Ca-rich plagioclase, Izu-Oshima volcano