

Magma plumbing system Ofunato and Tsubota stage in Miyakejima volcano based on high-pressure experiments and melt inclusions

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Miyakejima is an active tholeiitic volcanic island located at about 200 km south of Tokyo in Izu-Mariana arc. Miyakejima is a typical volcano in immature arc crust. For the last 10,000 years of Miyakejima volcano, geologic studies (e.g. Tsukui and Suzuki, 1998), petrologic studies (e.g. Niihori et al., 2003) and geochemical studies (e.g. Yokoyama et al., 2003) were extensively carried out. Tsukui et al. (2001) divided the volcanic activity of the last 10,000 years into four stages: 10-7ka (Ofunato Stage), 4-2.5ka (Tsubota Stage), 2.5ka to AD1154 (Oyama Stage) since AD1469 (Shinmio Stage). Niihori et al.(2003) said products of the Ofunato Stage were basalts and they were relatively primitive. On the other hand, products in Tsubota Stage were andesites and those in the latter two stages were mixed products of basalt and andesite. Precise knowledge of depth, temperature, water content and fO₂ of magma chamber are essentially important in discussing evolution of magma plumbing system. The purpose of this study is to investigate the evolution of the magma plumbing system in Miyakejima in the last 10ka based on high-pressure experiments and petrology. We show that a simple system in the Ofunato Stage developed into a complex one and this accounts for the change in chemical and petrologic features in the subsequent stages of Miyakejima volcano.

To understand the evolution of the magma plumbing system, first we studied the magma chamber in Ofunato Stage by high-pressure experiments. Experiments were performed at 1.0, 1.5, 2.0, 2.5kbar with various H₂O content using IHPVs (SMC-2000 and SMC-5000) at the Magma Factory, Tokyo Tech. Based on the experimental results and petrology of products in Ofunato Stage, magma chamber in Ofunato Stage was reconstructed. The magma chamber was located at 5~6km depth (~1.5kbar) and water-rich (~3wt.%) basalt magma crystallized olivine and calcic plagioclase (which is the typical phenocryst assemblage throughout Ofunato Stage). Volatile content (H₂O, CO₂, S and Cl) of melt inclusions were analyzed by FTIR and EPMA. Maximum H₂O and CO₂ content of a melt inclusion in olivine are 3.3wt.% and 160wt.ppm, respectively. The gas saturation pressure of magma indicates that the pressure of magma chamber in Ofunato Stage should be at least ~1.5kbar.

Whole rock compositions in pre-Ofunato, Ofunato and Tsubota stage, some of which were new data, were analyzed by XRF. A series of crystallization trends were calculated using MELTS program (Ghiorso and Sack, 1995), and it is found that andesites erupted in Tsubota Stage can be formed by fractional crystallization of OFS basalt at pressure less than 1.5kbar which corresponds with that of shallow level chamber in the two-layered magma chamber after Shinmio stage (e.g. Amma-Miyasaka and Nakagawa, 2003, 2005; Saito et al.2005, 2010). Postulated water content in magma (~0.6 wt.%; water-saturated pressure of basalt for this water content is less than 1.0kbar), however, is much lower than in Ofunato Stage (~3 wt.%). Accordingly, it is suggested that magma chamber has been significantly degassed in the shallow level chamber (0.6 wt.% H₂O in magma) during the dormant period (4~7kyBP).

Keywords: Miyakejima, Magma plumbing system, Magma chamber, High-pressure experiments, Melt inclusions