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Magma ascent and degassing of the 2000 Eruption of Miyakejima Volcano: New evidence from olivine-hosted melt inclusions

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Chemical analyses of 57 olivine-hosted melt inclusions and their host olivines from the explosive eruption on 18 August 2000 at Miyakejima volcano, Japan, were carried out by EPMA and SIMS in order to investigate magma plumbing system of the eruption. Bimodal olivine core composition, relatively small rims and diffusion profiles of Mg-rich olivines indicate mixing of evolved magma and less-evolved magma in two months before the eruption. Mixing ratio of the less-evolved magma to the evolved magma is very small considering the rare occurrence of the Mg-rich olivines in the products. Major element composition of Mg-poor olivine-hosted melt inclusions (Mg-poor OLMIs) is similar to that of groundmass and whole rock composition of the 1983 eruption products. Mg-rich olivine-hosted melt inclusions (Mg-rich OLMIs) have SiO_2-poor and K_2O-poor but Al_2O_3-rich and CaO-rich composition than whole rock composition of the 18 August 2000 products. The whole rock composition can be explained by 40 wt.% fractional crystallization of the melt represented by the Mg-rich OLMIs. Most of the Mg-rich OLMIs have slightly higher H_2O (1.9-3.5 wt.%), CO_2(0.003-0.025 wt.%) and S (0.06-0.21 wt.%) and lower Cl (0.04-0.07 wt.%) contents than those of the Mg-poor OLMIs. Variation of H_2O and CO_2contents of the inclusions and calculation of gas saturation pressure suggests that degassing occurred by pressure decrease of the evolved magma at a pressure range of 20-100 MPa and of the less-evolved magma at a pressure range of 50-150 MPa. Ratios of H_2O and S contents of Mg-rich OLMIs are similar to that of volcanic gas emitted from the summit after the 2000 eruption, suggesting shallow degassing of the less-evolved magma in the conduit since the eruption.
On the basis of these results, we considered the magma ascent and degassing processes of the eruption, assuming that shallow and deep magma chambers located at the depth of about 4 and 10 km, respectively, before the 2000 eruption. The deep magma chamber was composed of the less-evolved magma (C magma) having major element composition of the Mg-rich OLMIs. The evolved magma (B magma) was made by fractional crystallization of the C magma in the deep chamber and the B magma ascended from the chamber to the shallow magma chamber. In the shallow magma chamber, fractional crystallization of the B magma made the magma of the 1983 and 2000 submarine eruptions (A magma). The melt of the B magma was presumed to be volatile-poor because of decomposition degassing of the magma during its ascent from the deep magma chamber. We estimated that addition of CO_2-rich gas to this degassed and evolved magma (B magma) in the shallow chamber occurred to form melt represented by Mg-poor OLMIs. On the assumption that the CO_2-rich gas was supplied by degassing of the deep-seated C magma, mass balance calculation indicated that amount of the C magma required for supply of the CO_2-rich gas is about 70 times as much as the B magma. Just before the 2000 summit eruption, the C magma ascended from the deep chamber to inject into the B magma and erupted as the mixed magma.

Keywords: Miyakejima volcano, magma ascent and degassing, melt inclusion, volatile, olivine, SIMS