Water content in plagioclase-hosted melt inclusions of the Okama pyroclastics at Zao volcano, northeastern Japan: implications for magma ascent processes

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Zao volcano is a representative Quaternary volcano located in the central part of the volcanic front of northeastern Japan. The latest crater, Okama, started its activity (Okama pyroclastics, hereafter Okp) from ~1200 CE. The activity of Okp was characterised by small-scale (VEI=1–2) phreatic or phreatomagmatic eruptions. Revealing magma ascent processes that cause these small-scale eruptions is critical for prediction. Here, we examine magma ascent processes using the plagioclase-hosted melt inclusions for Okama pyroclastics at Zao volcano in northeastern Japan.

The rocks belong to the medium-K calc-alkaline series. The bulk rock compositions are basaltic andesite to andesite (~57 wt% SiO_2), whereas the groundmass compositions are andesite to dacite (~62 wt% SiO_2). The phenocrysts are plagioclase, orthopyroxene, clinopyroxene, and Fe–Ti oxides. Olivine phenocrysts are present in a few samples. Plagioclase and orthopyroxene outermost rim compositions show unimodal distribution (An 67 and Mg# 66). The temperature, pressure, and H_2O contents of the melt that equilibrated with the outermost rim of plagioclase and orthopyroxene phenocrysts were estimated using the orthopyroxene-liquid thermometer, orthopyroxene-liquid barometer, and plagioclase-liquid hygrometer. The estimated melt physicochemical conditions were 1025˚C, 200 MPa, and 3.0 wt% H_2O.

In this study, the H_2O contents in the plagioclase-hosted melt inclusions were measured by the FT-IR method. The contents range from 0.8 to 2.8 wt% H_2O. The H_2O saturation pressures range from 10–80 MPa.

The estimated water content from the plagioclase-liquid hygrometer reflects pre-eruptive condition at the magma reservoir. In contrast, the analysed water content in melt inclusion might be modified by re-equilibration during magma ascent. Even if melt inclusions were enclosed in host plagioclase crystal, water in the melt inclusion may have escaped to the surrounding degassed melt through intracrystalline H^+ diffusion. The re-equilibration degree depends on the melt inclusions' size and distance from the crystal rim. Therefore, the widely distributed water content of the melt inclusions indicates that these inclusions have undergone varying degrees of re-equilibration. Re-equilibrated water contents in the melt inclusions suggest a relatively slow magma ascent. Considering that the lower limit of water content in the melt inclusions reflects the fragmentation depth of the magma, the magma is estimated to have fragmented at a depth of <0.4 km (assuming a magma density of 2500 kg m-3 and static rock pressure).

Keywords: Magma ascent, Melt inclusion, Decompression rate, H2O diffusion, Plagioclase, Zao volcano

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