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Effect of pre-existing crystals and melt homogeneity on the decompression-induced crystallization of hydrous rhyodacite magma

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Decompression of hydrous magmas leads to dehydration and change in the liquidus temperature, resulting in crystallization. During magma ascent to the surface, the decompression-induced crystallization causes an increase in magma viscosity and eventually magma fragmentation. The magma crystallization is controlled by crystal nucleation and growth. Magma cooling experiments demonstrated that crystal nucleation is strongly influenced by the pre-existing crystals and melt homogeneity; however, no experimental works have investigated the effects of pre-existing crystals and melt homogeneity on the decompression-induced crystallization. In this study, we prepared five starting materials from rhyodacite pumice of Usu volcano (Japan) via heating at different temperatures (900–1300ºC) under 130 MPa pressure to investigate the effect of pre-existing crystals and melt homogeneity on the decompression-induced crystallization. For the prepared starting materials, decompression experiments from 130 to 30 MPa were conducted at a temperature of 900ºC. When the melt was completely homogenized at 1050 and 1300ºC, no crystals were formed at 100 MPa h^{-1}. In contrast, the heterogeneously formed crystals along the capsule wall were found at 5 and 20 MPa h^{-1}. At the same decompression rate, the number density of crystals increased as the heating temperature decreased, despite the higher number densities of pre-existing crystals in the starting materials with lower heating temperatures. Such findings indicate that nucleation occurs easily even when the number density is initially high. This result contradicts the idea that nucleation occurs when supersaturation is sufficient to overcome the energy barrier for nucleation, and the growth of pre-existing crystals decreases supersaturation. In contrast, our results can be explained by considering that higher heating temperature results in a more homogeneous melt structure with few pre-crystal clusters and ultimately the suppression of nucleation. For application to natural systems, the high number density of microlites found in natural samples may be due to heterogeneous nucleation caused by the presence of pre-crystal clusters. Furthermore, the heating of magma in a reservoir caused by the injection of high-temperature mafic magma may influence the crystal texture during magma ascent and, hence, control the magma fragmentation and the explosivity of the eruption.