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In situ measurements of plagioclase growth using SIMS depth profiles of $^{7}Li/^{30}Si$: A means to acquire crystallization rates during short-duration decompression events

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Abstract

Numerous petrologic studies have attempted to determine crystal growth rates in volcanic systems through several methods, including analyses of crystal size distributions in natural samples and decompression experiments on hydrous magmas. Experiments have revealed that rim growth on existing crystals will occur under a wide range of decompression conditions and is favored under conditions of low to moderate undercoolings over microlite nucleation, which has typically been the focus of decompression-induced crystallization studies. For this study, samples of eruptive clasts were collected from a Vulcanian explosion that occurred following the July 12–13, 2003 dome collapse of Soufrière Hills volcano, Montserrat. Plagioclase phenocrysts were extracted and examined with secondary ion mass spectrometry (SIMS) depth profiling. Lithium inflection depths within the profiles, along with the observed time interval between the peak in the collapse decompression and the explosion that ejected the examined samples, were used to calculate the growth rates as a result of magma devolatilization, with an average of 8.3×10^{-8} mm/s. Anorthite content of the plagioclase rim growth indicates an average decompression magnitude of 40 MPa, inducing an undercooling of ~45 °C that favors crystal growth over microlite nucleation. However, variability in the final anorthite contents suggests that not all phenocrysts recorded an equilibrium composition reflecting accurate pressure conditions. In such events occurring over short timescales (<10 h), lithium is a more reliable indicator of decompression-induced growth than changing anorthite content due to lithium's rapid diffusivity.

Keywords: Plagioclase, lithium, decompression, SIMS, Soufrière Hills