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Geochemical variations in late-stage growth of volcanic phenocrysts revealed by SIMS depth-profiling

Kimberly Genareau,* Richard Hervig, and Amanda Clarke

School of Earth and Space Exploration, Arizona State University, Tempe, Arizona 85287, U.S.A.

Abstract

In the petrologic and geochemical study of volcanic rocks, microlites have become an important tool with which to determine magma decompression rate and ascent path prior to eruption. However, studies in experimental petrology and kinetic modeling indicate that growth of pre-existing phenocrysts will occur over a much wider range of decompression-induced undercoolings than microlite nucleation. Consequently, we have developed a method using secondary ion mass spectrometry (SIMS) depth profiling to measure geochemical trends recorded during the final stage of phenocryst growth.

To test and demonstrate the new method, we examined explosive and effusive eruptive products collected from Soufrière Hills volcano, Montserrat. Plagioclase feldspar crystals were removed from clasts of pyroclastic deposits. Phenocrysts were individually selected on the basis of euhedral morphology and a relatively homogeneous distribution of surface contamination, such as volcanic glass. Crystals were cleaned, embedded in In, and analyzed by SIMS in depth-profiling mode. We used an O_2^+ primary ion beam, which provides a faster sputtering rate than the typically utilized O^- primary beam. A normal-incidence electron gun is used for charge compensation. Ten isotopes were examined over 2–10 h periods and the resulting crater depth was determined. Data show variable trends in An, K, and Fe that we interpret to represent late-stage physical variations within the magma prior to eruption. The continuous chronology of geochemical data obtained from the SIMS analyses presented here provide information with unprecedented (~0.1 μm) resolution, allowing researchers to determine physical conduit conditions during magma ascent from the chamber to eruption at the surface.

Keywords: SIMS depth-profiling, plagioclase, phenocrysts, volcanic conduit, Montserrat