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# TOF-SIMS and electron microprobe investigations of zoned magmatic orthopyroxenes: First results of trace and minor element analysis with implications for diffusion modeling

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## Abstract

Zoned phenocrysts in volcanic rocks potentially provide an archive of magmatic processes. As a crystal grows and comes into contact with different melt batches, the chemical and textural signature of this journey is recorded within its crystal lattice. The timescale of some magmatic processes can be investigated through the relaxation of chemical gradients across crystal growth zones through the application of diffusion modeling techniques. One of the current limitations to diffusion modeling is the spatial and analytical resolution of the chemical profile that conventional techniques such as electron probe microanalyzer (EPMA), dynamic secondary ion mass spectrometry (SIMS), and laser ablation-inductively coupled plasma mass spectrometry (LA-ICPMS) can achieve. Here, for the first time, we present time-of-flight (TOF) SIMS (TOF-SIMS) data for zoning of orthopyroxene crystals from the May 1982 eruption of Mount St. Helens volcano, U.S.A., and cross-calibrate these data between backscattered electron images and EPMA. TOF-SIMS has the advantage of being able to achieve micrometer to nanoscale spatial resolution of major elements as well as analyses of light elements, such as Li, and trace and minor elements (Na, K, and Ni) at concentrations that cannot be achieved by EPMA, provided that convolution (overlap) effects and polyatomic mass inferences are carefully considered. With TOF-SIMS analyses we identified zoning of Li on a spatial scale (ca. 5–10 μm) that would be inaccessible to most other conventional analytical techniques. Preliminary results indicate that Li, a fast-diffusing element, may be introduced to the crystals in the minutes, hours, or days prior to eruption and may provide insights into pre-eruptive magmatic processes. Thus, TOF-SIMS has the potential to be a powerful tool for obtaining minor and trace element profiles across compositional interfaces within crystals at high-spatial resolution.

**Keywords:** TOF-SIMS, diffusion, orthopyroxene, Li