

SIMS depth-profiling of igneous phenocrysts: Examining trace element variations on the edge

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Geochemical variations in the edges of igneous phenocrysts may offer insight on the characteristics of the host magma chamber immediately preceding or during a volcanic eruption. Secondary Ion Mass Spectrometry (SIMS) in depth-profiling mode can provide this chemical information with sub-micron resolution.

SIMS was utilized to obtain major and trace element isotopic abundances as a function of depth into the surface of plagioclase phenocrysts. Plagioclase crystals were separated from scoria clasts collected from a 2000 vulcanian eruption of Vulcan Fuego, Guatemala using Electrical Pulse Diaggregation (EPD). This method generates a high-voltage plasma that preferentially separates the sample along grain boundaries. Plagioclase phenocrysts were collected and embedded in indium in a brass mounting disc.

We used a 12.5 kV O_2^+ primary beam on the Cameca ims 6f SIMS (O_2^+ was used instead of O^- to increase the sputtering rate). A polished crystal of Lake Co. plagioclase (Oregon) was tested to determine the best analysis conditions. Three plagioclase phenocrysts from the 2000 eruption of Vulcan Fuego were then analyzed. Positive secondary ions were accelerated to ~5 kV from the sample and an electron gun was used to neutralize positive charge build-up. Major (Na, Al, Si, Ca) and minor to trace (Li, K, Fe, Rb, Sr, Y, Ba) elements were studied. Total depth achieved within each of the three crystals was approximately six microns (3 hour analysis). The majority of the elements showed stable ion signals throughout the profile (although K variations in the first micron were noted). Earlier work in our lab showed that these analyses can achieve depths of ~25 microns, large enough to examine chemical variations in oscillatory-zoned plagioclase.

The sample preparation methods involved allow the direct analysis of crystal surfaces (and near surfaces) preserving the chemical characteristics that were recorded in the outer margins prior to eruption. Chemical characterization of the near-surface region of a suite of igneous crystals is in progress. SIMS depth-profiling can provide information on phenocryst chemistry useful to the study of pre-eruptive volcanic processes and magma composition.

SIMS analysis of chlorine at low contents in silicates: A new tool for upper-mantle geochemical studies

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Among the elements which are potentially useful as geochemical tools, chlorine is an ubiquitous candidate, since it constitutes a window on the fluid-rock interactions in the Earth. Due to its volatile character, however, Cl cannot be measured in solid samples by flame or ICP atomic spectrometry. Cl contents higher than tens of ppm are nowadays generally obtained by INAA or EMPA. The SIMS procedure developed at CNR-IGG (PAVIA) for Cl analysis, which relies on 12.5-kV ^{16}O primary beam, energy-filtered (75-125 eV) secondary ions of both isotopes $^{35}Cl^+$ and $^{37}Cl^+$, and $^{30}Si^+$ (as the inner standard) under the 25- μm imaged field, has been optimized to measure low Cl concentrations (ppm level) in silicates, and applied to peridotite minerals. It allows the concomitant detection of light, alkaline, alkaline-earth, HFS and RE elements at the same micro-spot.

In this work we report and discuss the SIMS data for Cl obtained on upper-mantle peridotites (previously characterized in terms of light and trace elements, Ottolini *et al.* 2004) and on a new suite of xenoliths from Massif Central. Preliminary results indicate that the pyrolite contains between 5 and 10 ppm Cl, in the lower range of literature data. Main minerals of depleted peridotites (ol, opx, cpx) host 2-5 ppm Cl, but sp contents are below the SIMS detection limits. In general, the distribution of Cl appears to be very homogeneous in minerals with "primary" geochemical overprints (composition, texture) contrary to metasomatized phases, in which Cl contents can vary by two orders of magnitude at a very small scale. Our SIMS data confirm the highly-incompatible character of Cl in the peridotite-basalt systems.

Reference

Ottolini L., Le Fèvre B. And Vannucci R., (2004), Earth Planet. Sci. Lett. 228, 19-36

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