SIMS Analysis of Volatile and Lithophile Trace Elements in Igneous Materials: Advances and Challenges

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SIMS methods for analysis of lithophile trace elements in silicate minerals and glasses go back several decades already and their contributions to solid-earth geochemistry have been well documented. Studies of zoned minerals exemplify useful spatial resolutions provided by SIMS, including age-zoned zircons, chemically zoned phenocrysts and metamorphic minerals, as well as chemically heterogeneous garnet inclusions in diamonds. SIMS methods have also been successful in geothermometry and geospeedometry, and in determining diffusion profiles in experimental systems. Addition of volatile elements (CO_2, H_2O, F, S, Cl) in the repertoire in relatively recent years has expanded usefulness of SIMS in studies of volatile fluxes through mid-ocean ridge basalts, and of degassing of magma bodies. Capabilities of SIMS in providing isotope data for minerals, glasses and glass inclusions (D/H, δ^7Li, δ^{11}B, δ^{34}S, Pb, among others) further contribute to advancement of our understanding of igneous processes and deep recycling of elements. Examples of recent advances include: (1) D/H evidence for post-entrapment diffusive loss of hydrogen from olivine-hosted melt inclusions, (2) experimental determinations of melt-fluid sulfur isotopic fractionation factors, (3) large sulfur isotopic variations in olivine-hosted melt inclusions from MORB, and (4) benchmarking of boron isotopic composition of the upper mantle through MORB glasses.

Challenges to SIMS techniques are derived from processes of sputtered ion formation, and require continuing efforts for developing standard materials. For significantly increasing number of secondary ions, laser post-ionization should be seriously developed.