Secondary ion mass spectrometry (SIMS) for stable isotope microanalysis of trace light elements: the determination of ä^{11}B and ä^{37}Cl in small objects

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Secondary ion mass spectrometry (SIMS) has several general advantages for the determination of light stable isotopes occurring at trace element concentrations in natural samples. Ion microprobe SIMS instruments sputter nanogram quantities of material from a well-defined, micrometer-sized analytical crater. The extremely small quantity of sample extracted allows analysis of very small objects, for example, igneous melt inclusions.

Sputter ionization of many light elements (e.g., Li, B, S, Cl) is efficient enough (>>l%) to allow precise determination of isotope ratios at elemental concentrations as low as 1 – 100 ppm. Primary bombardment of the sample is performed in close proximity to the initial extraction optics of the mass spectrometer, enabling very stable and efficient secondary ion collection. Consequently, instrumental mass fractionation (IMF) can be maintained at a very consistent and reproducible level.

B isotopes. Use of SIMS for the determination of ä^{11}B is simplified because compositionally diverse matrices are amenable to calibration for IMF with a single standard. This attribute is particularly convenient in subduction-related volcanic systems, where tephra sequences may contain a wide spectrum of major element chemistries. For example, the combination of ä^{11}B and trace element microanalyses has been particularly valuable in modeling the contribution of a metasomatized mantle wedge to the Neogene Izu Arc Front volcanics.

Cl isotopes. ä^{37}Cl is readily amenable to SIMS microanalysis in a variety of matrices, due to the vigorous ionization of Cl (as Cl$^-$) under bombardment by positive primary ion beams such as Cs$^+$ Determination of ä^{37}Cl in glassy matrices requires using a Normal Incidence Electron Gun (NEG) to compensate for sample charging. A series of well-typified standards are also essential to calibrate for IMF, which can vary up to 10 per mil relative between basaltic and rhyolitic matrices. However, precise determinations of ä^{37}Cl are possible for glasses or silicate minerals with as little as 100 – 200 ppm total Cl. With special preparation, ä^{37}Cl can also be determined in microlitre aliquots of some natural fluids, containing as little as 1 microgram of total Cl.