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Lithium Isotope Measurements Using Thermo Scientific NEPTUNE Multicollector ICP-MS

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Key Words

- NEPTUNE
- International Rock Standards
- Lithium Isotopes
- Multicollector ICP-MS
- NIST L-SVEC
- Static Collection

Introduction

Precise isotopic analysis of Li is required in a number of different applications, including geochemistry and nuclear sciences. Thermal Ionization Mass Spectrometry (TIMS) is the preferred technique used for precise measurements of the $^{7}Li/^{6}Li$ ratio. A new technique for Li isotope analysis is Multicollector Inductively Coupled Plasma Mass Spectrometry (MC-ICP-MS) (e.g. Tomascak et al. 1999a,b). Here, we report on the short-term reproducibility of Li isotope analyses of NIST L-SVEC lithium carbonate standard and two international rock standards, BHVO-1 (USGS) and JG-2 (GSJ) with the Thermo Scientific NEPTUNE MC-ICP-MS.

Experimental

Samples are introduced in the ICP using a low flow self-aspirating PFA concentric nebulizer (uptake rate ~ 80 µl/min) and a quartz dual spray chamber ("stable introduction system"). The Thermo Scientific NEPTUNE MC-ICP-MS allows simultaneous measurement of $^{6}Li^{+}$ and $^{7}Li^{+}$ using the moveable low mass and high mass Faraday cups of the collector array (on platforms L4 and H4, respectively). The analysis sequence was: blank, L-SVEC standard, blank, sample 1, blank, L-SVEC standard, blank, sample 2, blank etc., so that the blank (an 'on peak' zero) was measured before and after each sample or standard. 0.5% Triton X100 (Merck) was added to standards, samples and blanks to improve beam stability. After initial uptake of sample (60 s), the analysis was started.

The reproducibility of Li isotope measurements was evaluated by analyzing a 200 ppb Li L-SVEC standard giving a typical ^{7}Li beam intensity of ~4 V (4 x 10^{-11} A at 10^{11} Ω resistor). With an uptake rate of 80 µl/min, approximately 80 ng of sample were consumed during one analysis lasting about 5 minutes (3 blocks of 10 ratios, 8 s per ratio measurement). To minimize memory effects, the aspiration system was rinsed for at least 5 minutes in 3% HNO_3 after each analysis to ensure that an appropriate blank value is reached.

Results

L-SVEC Li Standard

Figure 1 shows the short-term reproducibility of the Li isotope measurements on the L-SVEC standard solution. One analysis of three blocks (30 ratios) results in an internal precision of ~ 0.2 ‰ (1 σ). The external reproducibility (n = 8) for $^{7}Li/^{6}Li$ is also about 0.2 ‰ (1 σ). While the mass bias is large, around 25 % per amu ($^{7}Li/^{6}Li$ L-SVEC = 12.02 ± 0.03 ‰; Flesch et al., 1973 vs. 15.0-15.2 ‰, Figures 1 and 2) and varies with time, long-term variations are rather small (within 2 %) and the $^{7}Li/^{6}Li$ ratio of the L-SVEC standard varies around a mean of 15.

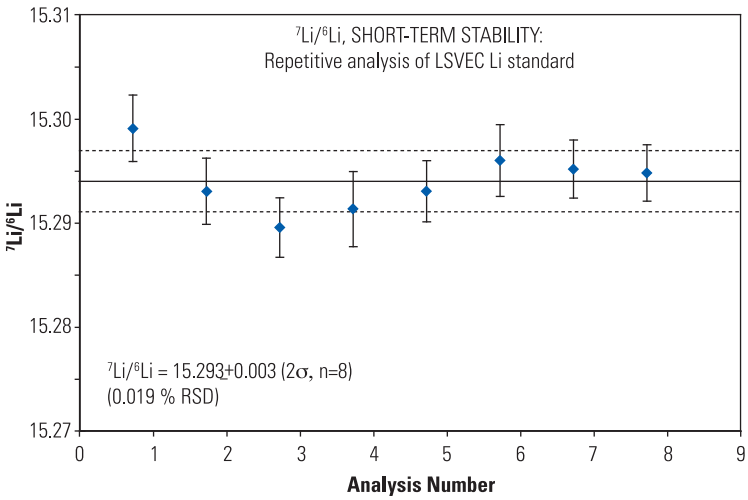

Figure 1: Short-term reproducibility of Li isotope measurements (L-SVEC Li standard, 200 ppb). Duration: 4 hours.

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International Rock Standards

Li isotope analyses of two international standards, BHVO-1 and JG-2, were performed to ensure the reliability of Li isotope data obtained by MC-ICP-MS. The measured $^{7}Li/^{6}Li$ of the samples were normalized to the mean of the measured $^{7}Li/^{6}Li$ of the standard runs before and after (linear interpolation). Data are presented as deviations of the measured $^{7}Li/^{6}Li$ in part per thousand from the $^{7}Li/^{6}Li$ of the standard ($\delta^{7}Li$).

$$\delta^{7}Li\ (‰) = \left(\frac{R_{sa}}{R_{st}} - 1 \right) \times 10^{3}$$

where R_{sa} is the $^{7}Li/^{6}Li$ ratio of the sample and R_{st} is the $^{7}Li/^{6}Li$ ratio of the L-SVEC standard.

Figure 2 shows the results of the Li isotope analyses of BHVO-1 and JG-2. The Li isotope compositions for JG-2 are in good agreement with the values reported by Oi et al. (1997) and James and Palmer (2000). There are no published data for BHVO-1. However, our results for BHVO-1 agree well with MC-ICP-MS analysis for a suite of other Hawaiian basalts, which define a range in $\delta^{7}Li$ of +3.0 to +4.8‰ (Tomascak et al., 1999b).

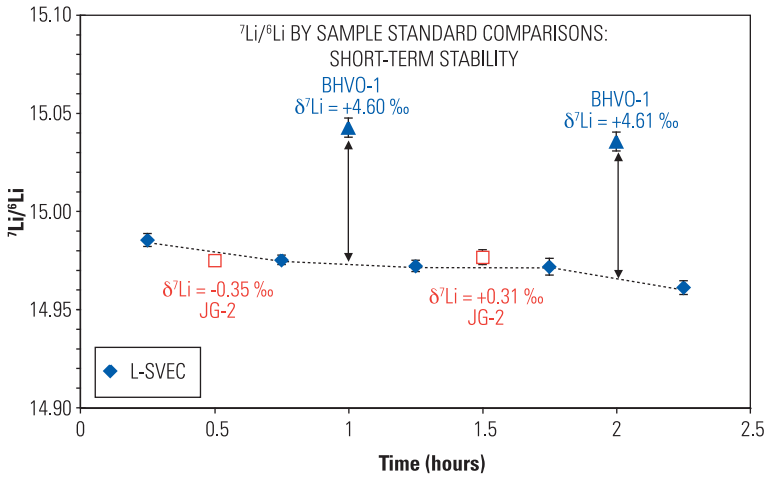

Figure 2: Li isotope analyses of international rock standards BHVO-1 and JG-2. δ values (in ‰) are given relative to the L-SVEC Li standard.

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