LITHIUM ISOTOPIC ANALYSES OF CHONDRITES AND CHONDRULES. W.F. McDonough1, F-Z. Teng2, R.L. Rudnick3, and R.D. Ash4. 1Department of Geology, University of Maryland, College Park, MD 20742 (mcdonough@geol.umd.edu)

Introduction: Light stable isotopes provide insights and constraints on nebular and parent body processes. Lithium isotope studies of chondrites offer such potential, with some specifically unique aspects. Lithium is monovalent, the lightest of non-fer such potential, with some specifically unique aspects. Lithium isotope studies of chondrites of- sights and constraints on nebular and parent body processes. It is also possible to use Li isotopes to study accretion evolution.

Analytical Methods: For the chondrite analyses, bulk rock and chondrule fragments were ground to a fine powder with an agate mortar, dissolved in high pressure bombs, and then dissolved in HF-HNO3. All samples were moni- tored for complete dissolution of solids. Chromato- graphic separation of Li was accomplished using a modified published procedure, the details of the method and our modifications are reported in [1-2]. Total procedural blanks were analyzed for concentra- tion and isotopic composition and determined to be negligible relative to the mass of sample (1-25 mg) analyzed. The Li isotopic measurements were performed on a Nu Plasma multi-collector ICP-MS at the University of Maryland. The δ7Li values for all samples are determined by comparison to the standard L-SVEC, measured before and after each sample analysis.[1-2]. The time-dependent monitoring of the absolute variation in δ7Li values of L-SVEC throughout the analysis session provides a further check on precision and accuracy of analyses, which are better than ±1‰ (2-sigma). During all analytical sessions we measured the δ7Li values of 2 or more reference materials (this includes processed rock standards) before each batch of samples and, where possible, after each suite of samples.

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Purified metals of isotopically enriched 7Li (>99% pure) and enriched 6Li (>99% pure) were prepared as solutions and mixed to produce solutions with an appropriate range of δ7Li values to calibrate the range of compositions encountered. These spikes were also added to selected in-house standard materi- als and these mixtures were analyzed and compared with their predicted compositions.

Results: In total, 19 chondrites were analyzed in this study; all but 2 (CV3 Efremovka and the EH3 Kota-Kota) are falls. The falls were selected to mini- mize earth-derived contamination. In addition, samples selected were chosen to obtain a representa- tive spectrum of chondrites. The average δ7Li value for all of the chondrites is 1.3 ± 1.3 (1σ). Twelve carbonaceous chondrites, including the groups CI, CM, CO, CV and CK, have an average δ7Li value of 1.7 ± 1.3. Six Allende chondrule fragments were analyzed and have an average δ7Li value of 1.1 ± 0.9, which is identical to the bulk Allende composition (δ7Li = 1.6). The 6 ordinary chondrites, including LL, H/L and H groups, have an average δ7Li value of 0.4 ± 2.0.

Discussion: There is a unimodal distribution of δ7Li values for all of the chondrites with considerable overlap in compositions for the carbonaceous and ordinary chondrites, although the ordinary chon- drite Krymka has a markedly lower δ7Li value (Fig. 1). The 3 samples plotting at a δ7Li value of +4 include the CI chondrites Ivuna and Orgueil and the CK4 chondrite Karoonda. The higher δ7Li values for the CI chondrites are unlikely to be a pristine nebular signature, but is suggested to be the result of parent body aqueous alteration processes. It is also likely that the higher δ7Li value of Karoonda is due to aqueous alteration processes on its parent body.

Fig. 1. A histogram plot of the δ7Li values of carbonaceous chondrites, ordinary chondrites and an enstatite chondrite. Also shown are data for 6 Allende chondrule fragments. The average δ7Li value for the chondrites is 1.3 ± 1.3 (1σ) and that for the chon- drules is 1.1 ± 0.9, which is identical to the bulk Al- lende (δ7Li = 1.6).
We have also run a series of tests that involved column chemistry of mixed solutions, doping of pure Li solution with known concentrations of “added contaminants” (specifically, alkali metals and alkaline earths) and the spiking of samples and standards with isotopically enriched \(^7\)Li and \(^6\)Li solutions. This extensive series of tests have provided us with documentation of what controls the accuracy and precision of the mass spectrometric analyses. It has also given us considerable insight into other factors that influence the fractionation process in the mass spectrometer. We have also analyzed experiments involving spiking of solutions (as well as geological standards (e.g., BHVO-2) and column chemistry) with isotopically enriched \(^7\)Li or \(^6\)Li spikes; these experiments provide an important control on the accuracy of our analyses. One of these experiments is highlighted in Figure 2. These and other experiments are used to establish the accuracy of our method over a range of \(\delta^{7}\)Li values between \(-50\) to \(+50\).

We have conducted tests documenting our limits of accuracy and precision down to 10 ppb solutions. Importantly, we have analyzed repeatedly the international Belgium SRM – standard reference material. During this time we matched the accepted \(\delta^{7}\)Li value [3] and found a factor of 6, or more, improvement in the precision for this SRM than that reported in [3]. In addition, we have analyzed our in-house standard (UMD-1) more than 100 times, with a 2-sigma precision of \(\pm 1.0\%\). Some of these analyses were performed on the solution that was processed through column chemistry in order to establish confidence in our column yields and as an additional check on column blanks envision. An example of these data is given in Figure 3.

Fig. 2. \(\Delta^{7}\)Li values versus error magnification value for multiple spiking experiments. These and other experiments demonstrate the accuracy over the scale of the observed variation of Li isotopic compositions. The over and under spiked runs were generated using mixtures of both enriched \(^7\)Li and enriched \(^6\)Li spikes added separately to different aliquots of UMD-1, an in-house reference Li solution. Error bars are 2 sigma.

The homogeneous composition of chondrule fragments from Allende can be compared with data reported for chondrules from Semarkona, which were obtained by SIMS analyses [4]. These 2 data sets compare favorably for their average \(\delta^{7}\)Li values, although the chondrule data from Semarkona show a 40% spread in values.


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