

UREILITE LITHIUM ISOTOPIC COMPOSITION. M. K. Garren¹, S. J. Singletary¹, D. R. Bell^{2,3}, and P.R. Buseck^{2,3}, ¹Dept. of Natural Sciences, Fayetteville State University, 1200 Murchison Road, Fayetteville, NC, 28301, ²School of Earth and Space Exploration, ³Department of Chemistry & Biochemistry, Arizona State University, Box 871404, Tempe AZ 85287; (mgarren@uncfsu.edu, ssingletary@uncfsu.edu, david.r.bell@asu.edu, pbuseck@asu.edu).

Introduction: Ureilites are primitive achondrites, consisting of olivine, pyroxene and carbon, that preserve a record of igneous processing during early solar system differentiation. They represent the second largest achondrite group, but their petrogenesis remains enigmatic. The ureilites are characterized by equilibrated, coarse-grained textures and mineral chemistry, but they retain primordial gas contents and oxygen isotope signatures [1]. Singletary and Grove [2] developed an olivine-pigeonite thermometer that reveals the majority of olivine-pigeonite-bearing ureilites equilibrated at temperatures above 1200°C. The lack of pyroxene exsolution features indicate that the ureilites must have cooled extremely rapidly [3] - most likely during parent body disruption. A feature common in ureilites is a reduced rim on the silicate phases (displayed most prominently on olivine) where in contact with the carbon-rich matrix or crosscut by veins of carbon-bearing material [4].

Lithium is one of the lightest elements, has high solid-state diffusivity [5], and has been analyzed in a wide variety of terrestrial and extraterrestrial materials [6-11]. Seitz et al. [6] measured lithium abundances and isotope compositions in a variety of chondrites. The $\delta^7\text{Li}$ value for carbonaceous chondrites is +3‰, similar to many terrestrial samples such as mantle olivine. Singletary et al. [10] reported average $\delta^7\text{Li}$ values for the El Gouanem ureilite of +6‰ in olivine cores, +20‰ in the reduced olivine rims and +6‰ in pyroxene. The range of measured $\delta^7\text{Li}$ values, however, spans -3.9‰ to +31.5‰. Because of lithium's high diffusivity, it may be uniquely suited to tracking vari-

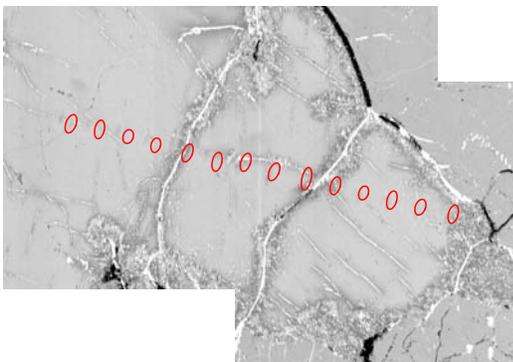


Figure 1. Backscattered-electron image of analysis traverse in PCA 82506. The red circles denote the location and size of the spot analysis. Image is approximately 1.5 mm across.

ous processes that occur over time scales of hours to days, such as the breakup of the ureilite parent body (UPB). This work expands on [10] by analyzing ureilites from a wider range of Mg#, ureilites with additional pyroxene assemblages and by adding spatial constraints on the lithium abundance and isotopic measurements.

Analytical Methods: Lithium abundances and isotopic composition of olivines and pyroxenes in the ureilites ALHA77257 (monomict olivine-pigeonite-bearing with Mg# 85), PCA 82506 (monomict olivine-pigeonite-bearing with Mg# 78) and MET 01083 (augite-bearing with Mg# 92) were measured using the Cameca 6f Ion Microprobe at Arizona State University in Tempe, Arizona using standard procedures [7]. Multiple traverses across several grain boundaries were carried out, measuring both lithium abundance and isotopic composition. Backscattered electron (BSE) images and secondary electron (SE) images of each traverse were taken in order to assess if co-mingled phases were analyzed. The composite BSE image of traverse 1 in PCA 82506 is shown in fig. 1, and the accompanying data are shown in fig. 2.

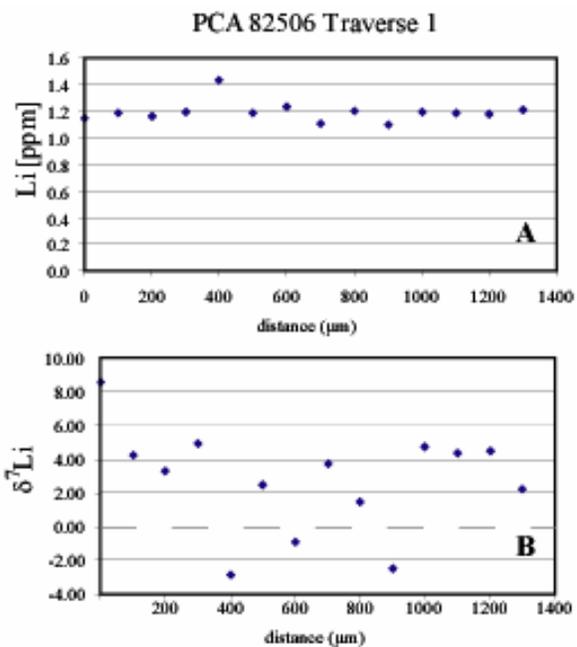


Figure 2. SIMS analyses of PCA 82506 traverse 1. The analyses correspond to the locations denoted in figure 1. The x axis corresponds to the distance between analyses. A) Li abundance in ppm B) $\delta^7\text{Li}$

Results: One hundred twenty analyses were collected along six traverses in the three samples. The average lithium abundance varies from 0.1 ppm in MET 01083 to 1.0 ppm in ALHA77257. A range of $\delta^7\text{Li}$ values were obtained, from -12 ‰ to +33 ‰. Along some traverses, $\delta^7\text{Li}$ values are flat in grain interiors and show evidence of disturbance near grain boundaries and along cracks in grain interiors (see figs 1 and 2). In general, $\delta^7\text{Li}$ values are lower near grain boundaries and cracks, but several cases exist where the opposite is observed.

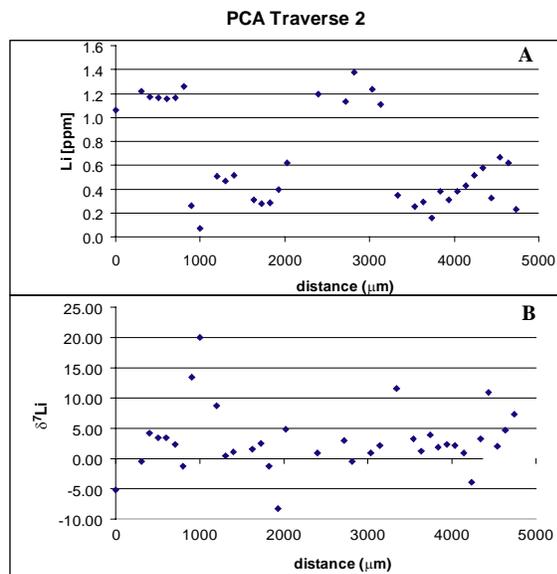


Figure 3. Data for PCA 82506 traverse 2 A) Lithium abundance and B) lithium isotopic composition.

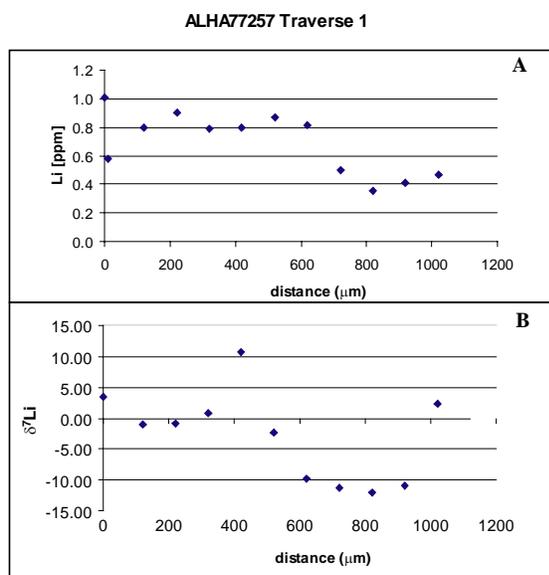


Figure 4. Data for ALHA77257 traverse 1 A) Lithium abundance and B) lithium isotopic composition.

Lithium abundance and isotope composition show evidence of diffusive transport, and diffusive profiles are preserved in both olivine and pyroxene (fig. 3 and 4). In some cases, $\delta^7\text{Li}$ values increase with lithium abundances, which are highest at the edges of olivine grains. The lowest abundances are in the interiors of pyroxene grains and display no systematic correlations with $\delta^7\text{Li}$ values. The reduced olivine rims contain the highest lithium abundance and $\delta^7\text{Li}$ values of all analyses (PCA 82506 - 1.6 ppm).

Based on several indicators, the most likely precursor materials for the ureilites are the carbonaceous chondrites [11,12]. Over the past few years, researchers have reached a consensus that ureilites represent the residues of a partial melting process [11-15]. The ureilites also preserve evidence of being held at high temperatures [2] and then cooled very rapidly. Based on the temperatures preserved in the ureilites and the speed at which lithium diffuses through olivine [16], it is surprising that adjacent olivine grains in PCA 82506 could preserve different lithium abundances.

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