SIMS ANALYSIS OF UREILTIE LITHIUM ISOTOPIC COMPOSITION. S. J. Singletary[1], D. R. Bell[2,3], and P.R. Buseck[2,3], [1]Dept. of Natural Sciences, Fayetteville State University, 1200 Murchison Road, Fayetteville, NC, 28301, [2]School of Earth and Space Exploration, [3]Department of Chemistry & Biochemistry, Arizona State University, Box 871404, Tempe AZ 85287; (ssingletary@uncfsu.edu, david.r.bell@asu.edu, pbuseck@asu.edu).

Introduction: Lithium is one of the lightest elements, has high solid-state diffusivity [1] and has been analyzed in a wide variety of terrestrial and extraterrestrial materials [2-5]. Seitz et al. [2] measured lithium abundances and isotope compositions in a variety of chondrites. The δ^7Li value for carbonaceous chondrites is +3‰; similar to many terrestrial samples such as mantle olivine (see figure 1). Because of lithium's high diffusivity, it is uniquely suited to tracking various processes that occur over time scales of hours to days, such as those processes inferred to have occurred during the differentiation of material in the early solar nebula.

Ureilites are primitive achondrites, consisting largely of olivine, pyroxene and carbon, that record igneous processing during early solar system differentiation. They represent the second largest achondrite group but their petrogenesis remains enigmatic. The ureilites are characterized by coarse-grained textures and equilibrated mineral chemistry, but they retain primordial gas contents and oxygen isotope signatures. Almost all ureilites contain reduced rims 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 [6].

Here we present the results of an analysis of lithium isotopic composition in the silicates of the El Gouanem ureilite. El Gouanem is a typical ureilite and consists of approximately 83% olivine and 17% pyroxene. The olivine has a Fo content of 80.5 and displays prominent reduction rims. The pyroxene is pigeonite with a wollastonite content of 7.8 and an enstatite content of 74.8. Reduced rims on the pigeonite are not readily noticeable. Lithium abundances and isotopic compositions of olivine and pyroxene in the El Gouanem ureilite were measured using the Cameca 6f Ion Microprobe at Arizona State University in Tempe, Arizona using standard procedures [3]. The data are shown graphically in figure 1.

Results: Forty one analyses of olivine display an average δ^7Li value of +6.29‰, with a minimum value of +0.45‰ and a maximum of +11.34‰. The lithium abundances are similar to those of terrestrial olivines of 1 to 3 ppm. Nine pigeonite analyses yield an average δ^7Li of +6.72‰, very similar to that of olivine, but a much larger range with a minimum δ^7Li value of -3.86‰ and a maximum δ^7Li value of +11.83‰. Eleven analyses of the reduced olivine rims yield a much higher average δ^7Li value of +20.14‰

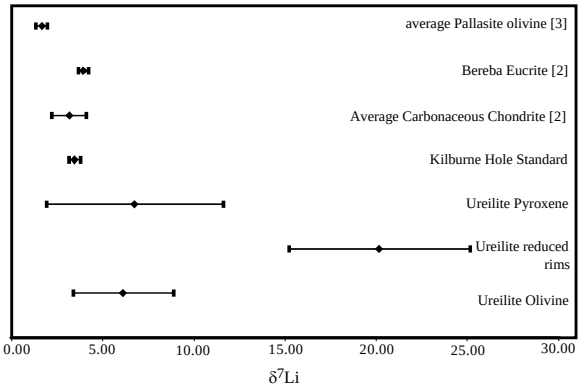

Figure 1. δ^7Li values of phases analyzed in this study and other meteorites for comparison.

and a similar range to that observed in the non-reduced olivine - minimum δ^7Li value of +15.46‰ and maximum δ^7Li value of +31.46‰.

Discussion: Based on several indicators, the most likely precursor materials for the ureilites are the carbonaceous chondrites [7, 8]. Over the past few years, researchers have reached a consensus that ureilites represent the residues of partial melting [9-12]. Several recent studies have concluded that Li diffusion results in an isotopic fractionation because the lighter ^{6}Li diffuses faster than ^{7}Li. This was shown experimentally for olivine [13]. Because Li is incompatible and prefers the solid phase, ^{6}Li will enter the melt preferentially in short-duration partial-melting events, leaving a residual isotopic composition enriched in ^{7}Li. The heavy lithium isotopic composition of the El Gouanem olivine suggests they are indeed the residue of a partial melt of a carbonaceous type precursor. During partial melting, olivine plus liquid will react to form pigeonite. The greater range in δ^7Li of the El Gouanem pigeonite suggests that these pyroxenes formed from a melt that could have been generated from melting of heterogeneous precursor.

The late-stage reduction rims displayed predominantly on the olivine grains are hypothesized to be a late-stage, high-temperature feature [14] that could have been created rapidly during parent body disruption. Experimental determination of Li diffusion in olivine has shown that Li can diffuse over several hundred microns in hours at high temperature [13]. The heavier δ^7Li values of the reduced olivine rims as compared to the core values suggests that melt was involved in the reduction process and stripped away the lighter Li isotope. The preservation of a lighter δ^7Li value in the olivine cores further suggests that

whatever process was responsible for the reduced rims must have occurred extremely rapidly.

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