OXYGEN ISOTOPIC ANALYSES OF CRYSTALLINE SILICATES AND OXIDES IN INTERPLANETARY DUST

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Introduction: We recently reported the discovery of abundant presolar grains in interplanetary dust particles [1]. While the majority of the grains found (29 of 30) appeared to be silicates based on the Si^-/O^- secondary ion ratios, only one grain was conclusively identified mineralogically (forsterite) by coordinated transmission electron microscopy (TEM). Mineralogical identification of the remaining grains was complicated by the fact that the analyzed IDPs were pressed into Au substrates. Here we discuss further analyses of IDP thin sections previously characterized by TEM, providing a first look at the oxygen isotopic compositions of a variety of specific minerals in IDPs on a submicrometer scale.

Experimental: The samples included in this study were fragments of anhydrous cluster IDPs: L2005 C13 (cluster 13), L2036 B6 (Cl 4), L2005 F31 (Cl 5 (Dragonfly)), and L2009 *E1 (Cl 7). Each of the IDPs was embedded in epoxy, sliced with a diamond ultramicrotome into ~70 nm sections, and transferred to a Cu TEM grid. We mapped the location of all grains >0.2 μm in each thin section, obtained energy-dispersive X-ray spectra, electron diffraction data, and dark field images of the crystalline grains.

After being characterized in detail by TEM, the IDP sections were subjected to oxygen isotopic imaging with the Washington University NanoSIMS ion microprobe. Images were acquired by rastering a ~2 pa Cs^+ beam over the sample and simultaneously measuring secondary $^{16,17,18}O$, ^{28}Si, and $^{24}Mg^{16}O$ ions with five electron multipliers. The spatial resolution of the images is ~ 100 nm. High mass resolution scans were taken on each sample prior to measurement to ensure that the ^{16}OH peak was well resolved from ^{17}O, with a mass resolving power of at least 9,000. The number of image scans acquired for each section was limited by the sputtering lifetime of the epoxy, which erodes much faster than the IDPs.

Results and Discussion: Of the five thin sections analyzed, 55 distinct subgrains were measured, including: 27 enstatite grains, 11 forsterite grains, 3 Fe-rich olivine grains, 10 apparently thermally altered olivine grains, 2 orthopyroxenes, and one grain each of anorthite, chromite, and Mg,Al,Ca-rich glass. The grains measured ranged from 0.2 μm to 4 μm in diameter, with most grains between 0.4 and 0.6 μm. Owing to the limited lifetime of the epoxy, only grains >0.2 μm in diameter yielded sufficient signal for isotopic analysis, while the smallest grains had typical counting errors for $\delta^{17}O$ and $\delta^{18}O$ of ~100 ‰ and ~40 ‰ respectively. Two presolar candidate grains were identified, one forsterite and one apparently thermally altered olivine grain, both exhibiting $^{16}O/^{17}O$ ratios of ~2,200, roughly 3–4 standard deviations away from the solar isotopic ratio (2610).

Significant populations of subgrains within the IDPs (up to 50 wt %) were too small to yield useful isotopic measurements for these samples. In order to study the smallest subgrains within IDPs, TEM-characterized sections will have to be transferred to Au substrates prior to isotopic analysis. The fact that the interstellar grain population is dominated by grains < 0.2 μm, and most of the presolar grains in IDPs found thus far had sizes of 0.2-0.3 μm provide additional motivation for taking this step.

References: [1] Messenger S., Keller L. P. and Walker R. M. (2002) *LPS 33*, Abstract 1887. [2] Kim S. H. et al. (1994) *ApJ* 422, 164.