THE MINERALOGY OF CIRCUMSTELLAR SILICATES PRESERVED IN INTERPLANETARY DUST

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Introduction: Interplanetary dust particles (IDPs) contain a record of the building blocks of the solar system including presolar grains, molecular cloud material, and materials formed in the early solar nebula [1]. Cometary IDPs have remained relatively unaltered since their accretion because of the lack of parent body thermal and aqueous alteration. We are using coordinated scanning and transmission electron microscope (STEM) and ion microprobe studies to establish the origins of the various components within cometary IDPs. Of particular interest is the nature and abundance of presolar silicates in these particles because astronomical observations suggest that crystalline and amorphous silicates are the dominant grain types produced in young main sequence stars and evolved O-rich stars [e.g. 2].

Experimental: We studied microtome thin sections of two anhydrous IDPs, L2005AL5 and L2011B10. Quantitative x-ray maps of the thin sections were obtained using a JEOL 2500 STEM. Following the TEM analyses, the sections were analyzed by O and N isotopic imaging in the JSC NanoSIMS 50L ion microprobe.

Results and Discussion: Six circumstellar grains have been identified including four amorphous silicate (GEMS) grains and two polycrystalline aggregates (EAs). All of these grains are between 0.2 and 0.5 μm in size. The isotopic compositions of five of the presolar silicate grains were reported by [4,5]. The new presolar GEMS grain is a group 3 grain (δ^{17}O -269, +/-69, δ^{18}O -61, +/-34) with an origin from either a low metallicity star or supernovae. The GEMS grains are chemically heterogeneous and contain nanophase FeNi metal and FeS grains in a Mg-silicate matrix. Two of the presolar GEMS grains are aggregates of smaller subgrains that show highly variable Mg/Si ratios in chemical maps. The polycrystalline grains show annealed textures (equilibrium grains boundaries, uniform Mg/Fe ratios, [4, 5]) and consist of 50-100 nm enstatite and pyrrhotite grains with lesser forsterite. One of the EAs contains a subgrain of diopside. The EAs likely formed by subsolidus annealing of amorphous precursors [5]. The bulk compositions of the six grains span a wide range in Mg/Si ratios from 0.4 to 1.2 (avg. 0.83). The average Fe/Si (0.43) and S/Si (0.20) ratios show a much narrower range of values and are ~50% of solar abundances. The latter observation may indicate a decoupling of the silicate and sulfide components in grains that condense in stellar outflows.

The heterogeneous chemistry and mineralogy of these GEMS grains show they were not extensively affected by irradiation, sputtering, or thermal processing and may represent relatively pristine circumstellar grains. They are strong candidates for the “dirty silicates” in astronomical observations of circumstellar dust shells. The EA grains were originally amorphous silicate grains that were likely annealed in the early solar nebula [6] while retaining their anomalous oxygen isotopic compositions.

References: [1] Messenger, S. *et al.* (2006) *MESS*, 187. [2] Molster, F. and Waters, L.B.F.M. (2003) *Astromineralogy*. Ed. T.K. Henning., Lecture Notes in Physics, vol. 609, 121-170. [3] Nittler L.R. et al. (1997) *ApJ* 483,475. [4] Keller, L. P. and Mesesnger, S. (2008) LPSC XXXIX, 2347. [5] Keller, L. P. and Messenger, S. (2009) *LPSC XXXX*, 2121. [6] Messenger, S. and Keller, L. P. (2010) *LPSC XXXXI*, 2483.