ABUNDANCE OF CIRCUMSTELLAR GEMS GRAINS

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Introduction: Silicate stardust grains in meteorites and interplanetary dust particles (IDPs) are compositionally and mineralogically diverse, with the majority being amorphous [1,2]. Most presolar silicates in IDPs are GEMS grains (glass with embedded metal and sulfides) [3], but only a minor fraction of GEMS grains shows substantial O isotopic anomalies [4]. Isotopically solar GEMS grains either had their isotopic compositions "homogenized" through processing in the interstellar medium (ISM) [3], or formed in the early solar system [4].

Here we present recent results on a systematic coordinated chemical, mineralogical, and isotopic survey of IDPs. The goals of this study are to identify and characterize stardust grains in detail as well as to better understand the origins of GEMS grains and other mineral components of IDPs.

Experimental: Fragments of two IDPs were studied: L2005 AL5 (cluster #13) and L2011B10 (cluster #6). The samples were embedded in elemental S (AL5) and epoxy (B10), and 70-nm thick microtome sections were deposited onto Cu TEM grids. The sections were fully characterized by transmission electron microscopy (TEM) with a JEOL 2500 FESTEM, including quantitative chemical imaging (EDX) and mineralogy. The sections were then subjected to O and N isotopic imaging with the JSC NanoSIMS 50L ion microprobe.

Results and Discussion: We identified four anomalous GEMS grains: two ^{17}O-rich grains (δ^{17}O=450‰, 1,000‰), one ^{18}O-rich grain (δ^{18}O=220‰), and one ^{17}O-depleted grain (δ^{17}O=-200‰). The probable stellar sources of these grains are AGB stars, supernovae, and low metallicity stars, respectively. Some of these data were previously reported [5]. The presolar GEMS grains were identified among a total of 177 GEMS grains >250 nm in size. Thus, approximately 2±1% of GEMS grains have large isotopic anomalies. This is roughly equivalent to the limit on the total fraction of surviving circumstellar material among GEMS grains we derive from their average O isotopic composition (-7.3±24.4‰,-.3±7.6‰; 2σ). If GEMS grains originated as circumstellar condensates with O isotopic compositions similar to presolar oxide grains (avg: δ^{17}O=1,870‰,δ^{18}O=-270‰)[6], the circumstellar material would need to be diluted by a factor of ~100 to reach their present average O isotopic composition. GEMS grains have either been completely homogenized in the ISM, leaving no trace of the original circumstellar condensates, or the majority formed in the Solar System. The average O isotopic compositions of crystalline silicates we measured were marginally ^{16}O-rich (-10‰) in comparison to average GEMS grains. This suggests that the host of a ^{16}O-enrichment previously reported in a GEMS-rich IDP [6] may be crystalline silicates, rather than GEMS grains.

References: [1] Messenger S. et al. (2003), *Science* 300, 105 [2] Nguyen A. et al. (2010), *Astrophys. J., in press* [3] Bradley J.P. & Dai Z. R. (2004) *Astrophys. J.* 617, 650 [4] Keller L. P. & Messenger S. (2010) *Geochim. Cosmochim. Acta, submitted* [5] Messenger S. et al. (2009) *Meteoritics & Planet. Sci.* 72,5357 [6] Aleon J. et al. (2009) *Geochim. Cosmochim. Acta* 73, 4558.