Washington University

"Presolar Grains Workshop"

"Origins of GEMS grains"

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Interplanetary dust particles (IDPs) collected in the Earth's stratosphere contain high abundances of submicrometer amorphous silicates known as GEMS grains. From their birth as condensates in the outflows of oxygen-rich evolved stars, processing in interstellar space, and incorporation into disks around new stars, amorphous silicates predominate in most astrophysical environments. Amorphous silicates were a major building block of our Solar System and are prominent in infrared spectra of comets. Anhydrous interplanetary dust particles (IDPs) thought to derive from comets contain abundant amorphous silicates known as GEMS (glass with embedded metal and sulfides) grains. GEMS grains have been proposed to be isotopically and chemically homogenized interstellar amorphous silicate dust. We evaluated this hypothesis through coordinated chemical and isotopic analyses of GEMS grains in a suite of IDPs to constrain their origins. GEMS grains show order of magnitude variations in Mg, Fe, Ca, and S abundances. GEMS grains do not match the average element abundances inferred for ISM dust containing on average, too little Mg, Fe, and Ca, and too much S. GEMS grains have complementary compositions to the crystalline components in IDPs suggesting that they formed from the same reservoir. We did not observe any unequivocal microstructural or chemical evidence that GEMS grains experienced prolonged exposure to radiation. We identified four GEMS grains having O isotopic compositions that point to origins in red giant branch or asymptotic giant branch stars and supernovae. Based on their O isotopic compositions, we estimate that 1-6% of GEMS grains are surviving circumstellar grains. The remaining 94-99% of GEMS grains have O isotopic compositions that are indistinguishable from terrestrial materials and carbonaceous chondrites. These isotopically solar GEMS grains either formed in the Solar System or were completely homogenized in the interstellar medium (ISM). However, the chemical compositions of GEMS grains are extremely heterogeneous and seem to rule out this possibility. Based on their solar isotopic compositions and their non-solar elemental compositions we propose that most GEMS grains formed in the nebula as late-stage non-equilibrium condensates.