A New Isotopic Perspective on the Solar System's Stardust Inventory

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A minor, but important component of primitive Solar System materials are isotopically anomalous dust grains that formed in the outflows of evolved stars and in the ejecta of stellar explosions. Silicates constitute the most abundant type of such "presolar" dust available for single grain analyses [1]. Presolar silicates cannot be extracted from their meteoritic hosts chemically, but have to be identified in situ by secondary ion mass spectrometry (SIMS). The stellar sources of presolar silicates have been identified based on the grains' O-isotopic compositions. The vast majority (70–80 %) of presolar silicates, so-called Group 1 grains, have been attributed to low-mass (1.2–2.2 $M_{\odot}$) asymptotic giant branch (AGB) stars of ~solar metallicity [2]. A few percent of presolar silicates might come from 4–8 $M_{\odot}$ AGB stars experiencing hot bottom burning [3]. The remaining ~10–20 % mostly come from core-collapse supernovae (CCSNe), while a few grains might have formed in nova outbursts. Isotope measurements of major elements other than oxygen (e.g., Mg, Ca, Fe) have been challenging in the past, because of insufficient spatial resolution. The new Hyperion RF plasma O primary ion source installed on the Cameca NanoSIMS 50 at the MPI for Chemistry allows the precise measurements of Mg isotopes with improved spatial resolution (<100 nm, instead of >200 nm for the older duoplasmatron sources) [4]. Based on our new data, not all investigated Group 1 grains are compatible with a low-mass AGB star origin (in grains from such stars, only small, if any, enrichments in the heavy Mg isotopes would be expected [5]). Instead, some displayed large ^{25}Mg excesses and only small ^{26}Mg excesses, indicating CCSNe as their sources [6]. Several ^{25}Mg-depleted silicates are potential supernova condensates as well, and several grains with Mg- and O-isotopic signatures indicating possible formation around intermediate-mass AGB stars were also found. Thus, the stardust inventory of the Solar System appears to be more diverse, and contains a higher amount of grains from massive stars than anticipated.

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