High-resolution measurements of Mg, Si, Fe and Ni isotopes of O-rich presolar grains.

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Introduction: Presolar grains, hosted within the matrix of primitive meteorites, are windows into the nucleosynthesis of stars. Presolar O-rich grains, such as silicates and oxides, have been divided into partially distinct groups on the basis of their large O-isotope anomalies [1]. Group 1 encompasses the largest fraction of grains (~70%), and likely formed in outflows of low-mass AGB stars (1.2-2.2 $M_\odot$) and an AGB origin is also probable for the highly ^{18}O-depleted Group 2 grains [1]. Aside from possible radioactive decay products (*e.g.*, ^{26}Mg from ^{26}Al), nucleosynthesis in these stars is not expected to significantly modify Mg, Si, Fe or Ni isotopes [2,3,4,5]. As a consequence, the isotopic compositions of Group 1 presolar grains in those elements is thought to represent those of the parent stars, thus reflecting galactic chemical evolution (GCE). Mg isotopes have been extensively studied in presolar oxides [3,6,7] but very little in presolar silicates [2], the latter often having large errors owing to technical limitations [2,3]. These limitations were recently removed with the new Hyperion II RF plasma O primary ion source for the NanoSIMS that has already enabled high-resolution studies of Mg and Si isotopes in presolar silicates [5,8,9]. Here we report additional isotope measurements of those elements along with Fe and Ni isotopes in several presolar silicates and oxides from the Acfer 094 (ungrouped C3) meteorite.

Methods: Presolar grains were identified in Acfer 094 by O isotopic mapping (with a Cs^+ primary beam) in the Carnegie NanoSIMS 50L and analyzed for additional elements with the Hyperion II RF plasma O^- source. 18 presolar silicates and 3 oxides (19 group 1, 2 group 2) were measured for ^{24,25,26}Mg, ^{27}Al, and ^{28,29,30}Si isotopes in multicollection mode with a 0.5pA primary beam (~80nm resolution) over a 2×2μm^2 raster. Each measurement was normalized to its surrounding matrix. 11 grains were re-measured in a second session for ^{52}Cr, ^{54,56,57}Fe and ^{58,60,61,62}Ni isotopes in combined analysis mode with similar beam conditions over a 3×3μm^2 raster. Metal globules of the meteorite and the 519-4-1 glass were used as standards. We corrected for possible ^{54}Cr contributions to ^{54}Fe assuming a solar composition of Cr and ^{58}Fe contribution to ^{58}Ni in the same way.

Results & Discussion: Si-isotopic measurements of our grains are consistent with previous studies, *i.e.* roughly lining along the SiC Mainstream-line with δ^{29}Si and δ^{30}Si ranging between -35 to 204‰ and -14 to 176‰ respectively. Fig. 1 shows the large range of Mg-isotopes compositions recorded in O-rich presolar grains. We found fewer grains with close to solar composition and a larger scatter from the GCE trend than observed in previous studies. A few grains cluster around a ^{25}Mg-enriched composition close to 200‰ with solar to slightly enriched ^{26}Mg. In addition, a significant fraction of our grains depart from the GCE trend toward more ^{25}Mg-depleted compositions for δ^{26}Mg values close to 100‰. The isotope maps also revealed four grains with Mg and/or Si isotopic anomalies that were not identified on the basis of O isotopes; all have Mg and Si isotope compositions falling within the range of presolar silicates and oxides attesting to their presolar origin. One exhibits high enrichments in both ^{25}Mg and ^{26}Mg, falling close to the GCE trend (Fig. 1a). One Group 2 silicate grain has the highest enrichment in ^{25}Mg ever recorded with a δ^{25}Mg value of ~2000‰. It is unlikely that this composition can be reached in an intermediate-mass AGB star or novae. A supernova experiencing explosive H burning may explain this grain [9], but we suggest instead that a super-AGB star origin may be more likely [10]. Out of eleven grains measured, six exhibited Fe and possible Ni anomalies but data are still being processed.

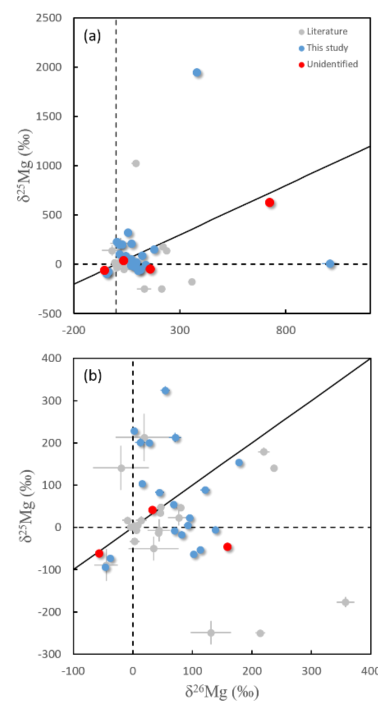

Figure 1 – Mg isotopes compositions of presolar grains in this study. Red circles represent Mg-anomalous grains of which no O-isotopic composition was acquired. Error bars are 1σ. Dashed line depict the solar composition. Solid line has a slope 1 and roughly represents the GCE trend.

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