Isotopic analysis of presolar dust grains with the NanoSIMS

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Although presolar grains isolated from primitive meteorites have been studied in detail for their isotopic compositions, most analyses have been limited to grains ≥1µm [e.g., 1, 2]. The NanoSIMS with its high sensitivity and high spatial resolution [3] makes it possible to analyze sub-micron grains, charasteristic of the size of interstellar dust [4]. This capability has resulted in several isotopic studies of grains that previously would not have been possible.

One example is the analysis of presolar spinel grains from the Murray carbonaceous chondrite [5]. Oxygen isotopic measurements showed that the abundance of presolar grains ≤0.5µm is much higher (~2% of all spinel grains) than that of ≥1µm grains (~0.1%). Magnesium isotopic measurements of these presolar spinels revealed large ^{26}Mg excesses [6]. Inferred initial ^{26}Al/^{27}Al ratios are much higher than expected from shell H burning in asymptotic giant branch (AGB) stars and require extra mixing (cool bottom processing).

Another example is the discovery of presolar silicates in interplanetary dust particles (IDPs) [7, 8] and in primitive meteorites [9, 10]. These grains are ≤1µm and although their abundances are higher than those of most other presolar grain types identified so far (~180ppm in a primitive meteorite and ~890ppm in IDPs), only the analysis of many thousands of grains by high-spatial-resolution isotopic imaging has made their identification among an overwhelming majority of isotopically normal silicate grains of solar-system origin possible.

References

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O- and S-isotope imaging of primitive solar system materials with the Mainz NanoSIMS

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Introduction

Primitive meteorites and IDPs contain small quantities of nm- to µm-sized presolar grains that formed around evolved stars [1]. The invention of the NanoSIMS with its superior lateral resolution (<100 nm) and capability for the search of in-situ presolar dust in slices of IDPs [2] and meteorites [3] has opened a new window in this field of astrophysical research. Here, we will present results from NanoSIMS imaging surveys of O- and S-isotopic compositions in the Acfer 094 and Bishunpur meteorites and in two IDPs.

Acfer 094 and Bishunpur

O-isotope mapping with lateral resolution of 100 nm was performed on the matrix in polished thin sections of Acfer 094 and Bishunpur. Based on large O-isotopic anomalies we identified 17 presolar silicate and 3 presolar spinel grains, 150 to 600 nm in size. The O-isotopic compositions (and Si- and Fe-isotopic compositions, measured on a subset of those grains) point to origins from RGB and AGB stars. Matrix-normalized abundances are estimated to be 15 ppm (Bishunpur) and 130 ppm (Acfer 094) for silicates and 50 ppm for spinel (Acfer 094).

S-isotope mapping was done on selected areas of the matrix in Acfer 094. Automatic particle recognition revealed some 400 S-rich grains, two of which exhibit large negative ^{36}S/^{32}S anomalies of ~3σ. Whether these anomalies are just statistical outliers or the signature of real presolar matter remains to be seen.

IDPs U2071J2 and U2071C9

O-isotopic mapping was performed on four microtome sections of IDP U2071J2 (9×5 µm^2) and on seven microtome sections of IDP U2071C9 (12×8 µm^2). No presolar grains were found. Upper limits for presolar grains in these two IDPs of several 100 ppm are inferred.

References

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