NanoSIMS analysis of the Isotopic Composition of Presolar Silicon Carbide grains from the meteorite ALHA77307

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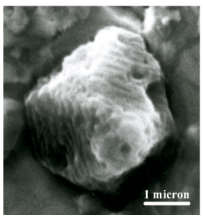
Introduction and Motivation

Presolar grains (stardust) condensed around stars of various types prior to the formation of our solar system. The isotopic ratios of stardust contain a record of the nucleosynthesis within the parent star, Galactic Chemical Evolution (GCE), and history of our solar system.

In order to test models of the origin of the solar system, we are developing a new data set on types of reservoirs present at the birth of our solar system.

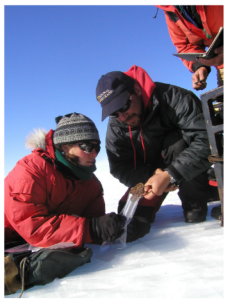
Cygnus Loop Supernova Blast Wave



Secondary electron image of SiC grain from the meteorite Orgueil

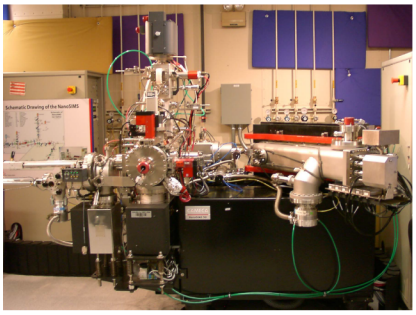
Much of the previous work focused on presolar silicon carbide (SiC) from two carbonaceous chondrites, Murchison and Orgueil, but several other types of meteorites have also been studied. Within one meteorite, the stardust originated from several different stellar sources. This study specifically targeted the isotopic composition of SiC in CO3 chondrites because there are limited data on this type of chondrite.

The main aim of this study is to test whether all chondrite classes sampled the same reservoir of presolar dust. To do this, it is necessary to look for primary differences, not related to thermal processing and metamorphism, between different types of presolar grains.

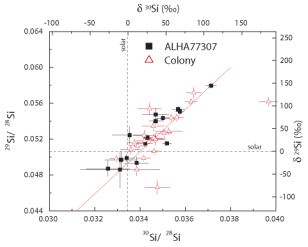


Collecting meteorites on an icefield in Antarctica. The sample ALHA77307 was found on the Allan Hills icefield in Antarctica.

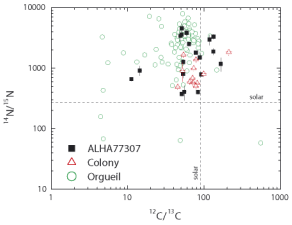
Experimental Methods and Results



- LLNL NanoSIMS 50 only one in the DOE complex
- state of the art ion microprobe was commissioned in June 2003
- imaging secondary ion mass spectrometer capable of 50 nm resolution
- this is the first application of the LLNL NanoSIMS to studies of presolar grains
- collected new isotopic data for C, Si, and N in ALHA77307, see the following diagrams

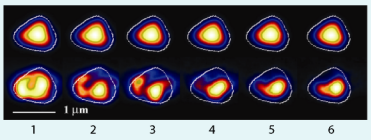


The grains have the characteristic non-solar Si isotopic signature. In other meteorites > 95% of the data lie on a linear correlation line representing GCE. Our new data from ALHA77307 fit this trend.



However, ALHA77307 is unusual in having so many high and low $^{12}C/^{13}C$ ratio grains. The N-isotopic ratios overlap those of other meteorites.

Depth Profile Through SiC Grain



^{12}C

$^{12}C^{14}N$

The array of images to the left is a depth profile through a grain as material is sputtered away. From Image 1 to 6, ~300 nm of material is removed. The top row shows that C distribution is uniform with depth. The bottom row representing N shows N abundance is heterogeneous within a single SiC grain; there is no evidence of N isotopic heterogeneity.

Summary

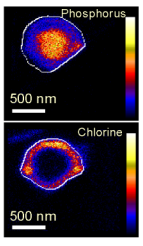
- using LLNL NanoSIMS, investigated C, N, Si isotopic compositions of 19 SiC grains in ALHA77307.

- N & Si isotope compositions fall within range seen in SiC from other meteorites. However, there is an unusually high abundance of grains with a wide range of $^{12}C/^{13}C$ ratios. This unexpected ^{12}C-enrichment and depletion indicates incorporation of grains from disparate stellar sources.

- unique to this study, is the first observation of N chemical heterogeneity within a single grain demonstrating sub-structure in SiC on a nm-scale. This gives new constraints on condensation within the stellar envelope.

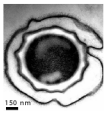
- high spatial resolution of NanoSIMS gives the possibility to look for subgrains which gives us a window back to evolution of the stellar

Application of techniques



Phosphorous and Chlorine images of *B. thuringiensis israelensis*

- NanoSIMS is unique for its high resolution chemical and isotopic imaging capability
- this has been applied to the study of spores currently undertaken in the NanoSIMS lab.



Bacillus cereus spore (CHORI)

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