HIGH SPATIAL RESOLUTION ISOTOPE RATIO IMAGING AND 3D RECONSTRUCTION OF PRESOLAR SiC GRAINS.

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Introduction: Isotope ratio measurements of $^{12}$C$/^{13}$C, $^{14}$N/$^{15}$N and $\delta^{28,30}$Si as well as the isotope systems of other elements have been obtained from thousands of presolar SiC grains over a period of >25 years [1]. Most of these analyses were however obtained with relatively poor spatial resolution (>1µm). Systematic high spatial resolution (<100nm) analyses of SiC grains have, in general, not been obtained and therefore no studies of isotopic heterogeneity within grains have previously been reported.

Many presolar SiC grains are polycrystalline with individual crystals in the <300nm size range and this study was designed to obtain isotope ratio images with sufficiently high spatial resolution and accuracy to determine whether there was isotopic heterogeneity within the grains. A particular target of study was to obtain $^{14}$N/$^{15}$N distributions with high spatial resolution as previous analyses by a range of SIMS instruments have obtained $^{14}$N/$^{15}$N for mainstream SiC grains ranging from 8000 to 290 (the terrestrial value) and 8000 to 50 for A+B SiC grains. This very large range is difficult to understand from nucleosynthetic models [2]. We note that if only high spatial resolution analyses of A+B grains obtained using a NanoSIMS in [1] are retained, then only $^{14}$N/$^{15}$N>1000 analyses remain. We also note that in A+B grains, the ratio of peak sizes of $^{13}$C$^{14}$N$^{15}$C$^{15}$N can be greater than 300 making the determination of $^{14}$N/$^{15}$N susceptible to systematic error leading to low values.

Experimental Methods: A new NanoSIMS 50L installed at the University of Manchester is equipped with 7 EM detectors to simultaneously acquire ion currents of $^{12,13}$C, $^{12}$C$^{14}$N, $^{12}$C$^{15}$N, and $^{28,30}$Si. A primary Cs+ current of ~0.5pA (D1-5 aperture setting) and spatial resolution ~100nm was used. Imaging SiC grains with a field of view typically between 1-3µm, depending upon the size of the grain, took between several hours to ~1 day to systematically sputter a single grain completely. 20 mainstream and one A+B grain were analysed in this study. They were from the KJG separate reported and supplied by [3].

Experimental Results: $^{12}$C$/^{13}$C and $\delta^{28,30}$Si were found to vary less than several tens of per mil (within errors determined by counting statistics) for ~100nm voxel domains within all grains.

However, the CN$^+$ distribution was highly complex within and around the grains and its isotopic composition could vary from 300$^{14}$N/$^{15}$N<4000. Some grains were observed to have CN- hotspots or a CN$^+$ halo around the grain with the terrestrial 14N/15N ratio indicating that measurements of $^{14}$N/$^{15}$N in SiC grains obtained with a spatial resolution poorer than100nm are potentially compromised with contamination by terrestrial nitrogen. This may potentially explain the range of $^{14}$N/$^{15}$N in mainstream grains reported in [1] and could reconcile the presolar SiC data with nucleosynthetic models.

Acknowledgements: We thanks S Amari for the KJG grains and permission to analyse them and K Moore and G McMahon for assistance with the NanoSIMS analyses.