COMPREHENSIVE ANALYSES OF GENTLE SEPARATED PRESOLAR SIC-GRAINS. T. Henkel[1], J. Tizard[1], and I. Lyon[1], [1]School of Earth, Atmospheric, and Environmental Sciences, the University of Manchester, Oxford Road, Manchester, M13 9PL, UK (torsten.henkel@manchester.ac.uk, ian.lyon@manchester.ac.uk).

Introduction: Presolar grains undergo a long journey through interstellar space before being incorporated into primitive meteorites from which they are recovered [1]. During this journey they are exposed to particle impacts and UV-radiation which might lead to alteration, accretion or sputtering effects leading to changes in structure and formation of coatings on the original refractory grain. Presolar grains may therefore preserve samples of the interstellar medium which may be analyzed if the grains can be extracted from meteorites without alteration.

Previous work has shown that the surfaces, and possibly deeper parts of the grains are altered by the acid extraction process [2]. Bernatowicz et al., [3] showed that ~60% of grains extracted using only an ultra-sonic extraction method have an amorphous coat which isn't found using acid-extraction methods. We developed an acid-free extraction method using freeze-thaw dissaggregation followed by size and density separation of SiC grains [4]. This is known as the gentle separation technique.

Samples: For this study, 9 SiC-grains extracted from the Murchison meteorite by the gentle separation technique were analyzed (GS grains) along with 11 (AR) grains from the KJG-fraction from the Murchison meteorite [5] for comparison.

Analytical Techniques: We used a time-of-flight secondary ion mass spectrometer [6] to obtain high spatial resolution and high lateral resolution analyses. The primary ion beam was finely focused and rastered over the sample surface to acquire a complete mass spectrum in every pixel of the image. From this raw data, secondary ion distribution images and mass spectra for the region of interest were reconstructed.

Atoms are sputtered from the sample so rastering the beam across the sample and acquiring several measurements therefore leads to a depth profile enabling a quasi 3-dimensional study.

Results:

Morphology. The AR-grains show the typical features as seen in previous studies and become very smooth during sputtering. By contrast, some GS-grains showed a very different behavior. Grains GS-D4-G2-1 started as an almost rectangular grain with a quite smooth surface but became very uneven during sputtering and grain GS-D4-Y1-1 changed from a smooth surface to a very pitted surface.

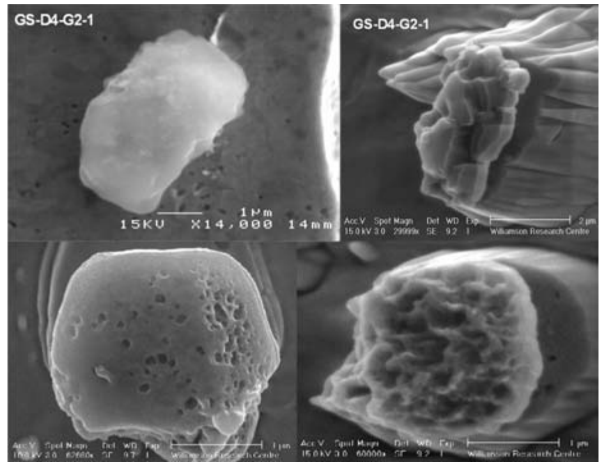

Figure 1 SEM images of grain GS-D4-Y1-1 (top) before and after measurements and Grain GS-D4-G2-1 (bottom) before and after measurements.

Isotope ratios. Isotope ratios for Mg and Si were determined for all grains to determine their classification. Si isotope ratios are shown in Figure 2. One grain showed a ^{26}Mg-excess from the decay of ^{26}Al resulting in an inferred, initial ^{26}Al/^{27}Al-ratio of $2.9(\pm1.0)\times10^{-3}$. From these isotope ratios type X and Z grains can be excluded and types A and B are unlikely because of their general low abundance. We infer that all measured grains were mainstream SiC-grains.

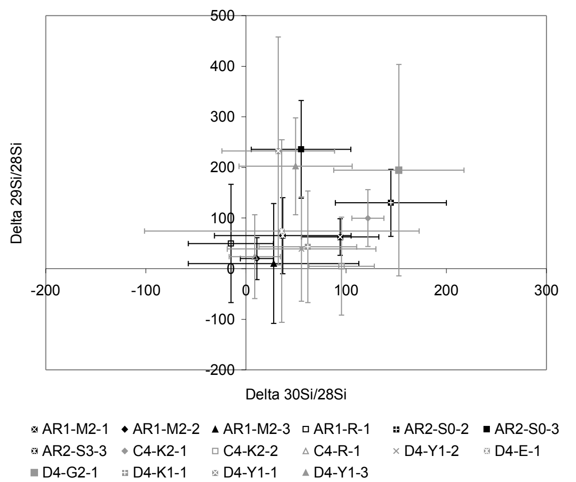

Figure 2 Si-3-isotope plot for all measured grains. Errors are 2σ. All grains are mainstream grains.

Elemental abundances. Figure 3 shows the average abundance pattern for the measured AR and GS grains compared to literature data from [7]. The results for

AR grains overlap as expected with the literature data determined from presolar SiC-grains from the Murchison meteorite but show a much wider variation and average values for the AR grains are up to a factor of four higher than literature values. The GS grains show similar abundances for Fe, Al, Cr, Ti, and V but significantly elevated ranges for Mg and Ca with variations as big as for AR grains. The average for Mg and Ca is around one order of magnitude higher than for AR grains.

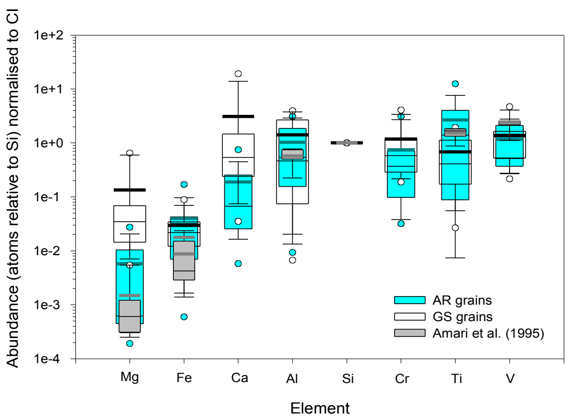

Figure 3 Overview of all measured elemental abundances. Our data for AR and GS grains is compared to literature data for AR grains.

There are large variations of up to 2 orders of magnitude between different grains and also large variations of up to 1 order of magnitude within a single grain while sputtering into it.

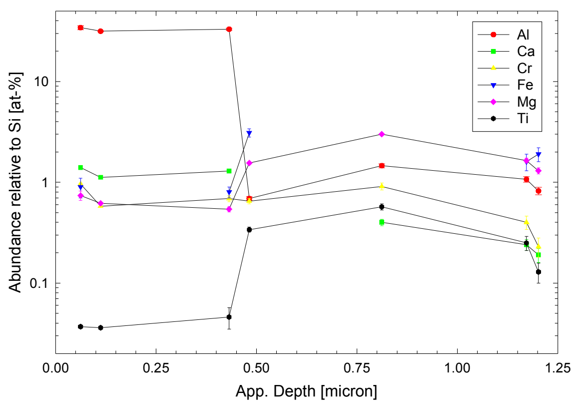

Figure 4 Depth profile of grain GS-D4-Y1-3 showing a huge change in several elements at a depth of around 0.45 micron.

Depth profiles. Most grains show a variation in the abundances of several elements from their outer layer into the inner core. For an example see Figure 4 which shows grain GS-D4-Y1-3 with an Al-rich and Ti-poor outer layer. Al and Ca abundances decrease with depth (Al more than one order of magnitude) and Fe, Mg, and Ti increase with depth.

Elemental correlations. Strong correlations have been found among the element abundances for the AR grains between Cr, Ca, Mg, and Fe with a weaker correlation between Mg and Fe. There are further weak correlations between Ti and Cr and Mg. The GS grains showed no correlations at all.

Discussion: The higher average elemental abundances for AR grains over published values [7] can be explained by the different measurement methods in which we have analyzed principally the outer layers of the grain whereas [7] presented data for averages of whole grains. If the outer layer of a grain is altered by the harsh acid extraction or has a genuinely different composition then it will change the average value. The correlation of several elements together with previous work [2] suggests that the outer layers are altered by the harsh acid treatment during extraction from the meteorite.

The high variation of elemental abundances of the GS grains can be explained by a coat-core structure of the grains which is also corroborated by the depth profiles. The nature of the coat can not be determined from the elemental and isotopic composition but the absence of any elemental correlations and the different composition suggests an authentic coat acquired before being incorporated into the host meteorite.

We therefore conclude that GS grains consist of a core mostly covered by a coat of different composition but are genuine presolar SiC grains. By contrast, AR grains consist of the core material only having lost their coatings and are altered by the harsh acid treatment.

References: [1] Lewis R. S. et al. (1987) Nature 326, 160-162. [2] Henkel T. et al. (2001) M&PS 36, A78. [3] Bernatowicz T. J. et al. (2003) GCA 67, 4679-4691. [4] Tizard J. et al. (2005) M&PS 40, 335-342. [5] Amari S. et al. (1994) GCA 58, 459-470. [6] Henkel T. (2006) RSI, submitted. [7] Amari S. et al. (1995) M&PS 30, 679-693.

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