PRESOLAR SIC ABUNDANCES IN PRIMITIVE METEORITES BY NANOSIMS RASTER ION IMAGING OF INSOLUBLE ORGANIC MATTER. J. Davidson[1], H. Busemann[1,2], C. M. O'D. Alexander[2], L. R. Nittler[2], D. L. Schrader[3], F. R. Orthous-Daunay[4], E. Quirico[4], I. A. Franchi[1], and M. M. Grady[1], [1]PSSRI, The Open University, Milton Keynes MK7 6AA, UK, j.davidson@open.ac.uk, [2]Department of Terrestrial Magnetism, Carnegie Institution of Washington, DC, USA, [3]University of Arizona, Lunar and Planetary Laboratory, Tucson, AZ, USA, [4]Laboratoire de Planétologie de Grenoble, Université Joseph Fourier CNRS, France.

Introduction: Here we present results obtained with NanoSIMS raster ion imaging to determine the abundance of presolar SiC in the insoluble organic matter (IOM) extracted from a number of different classes of chondrites (both carbonaceous and ordinary). This builds on previous work [1] aimed at obtaining SiC abundances in primitive meteorites by SIMS and comparing them with noble gas analyses.

Both IOM and presolar grains are found in similar CI-like relative abundances in the matrices of the most primitive chondrites [2, 3], indicating that a homogeneous mixture of grains was incorporated in the various parent bodies [3]. Both are then subjected to thermal and hydrothermal processing after parent body formation [4]. However, there are significant variations in the matrix-normalized abundances of SiC grains estimated from noble gases carried by presolar grains, which suggest that the primitive chondrites did not form from a well-mixed reservoir of presolar grains. Variations in the source material were attributed to the destruction of presolar grains by heating in the solar nebula (temperatures that may have exceeded 700°C) and were linked to the volatile element fractionations in chondrites [5].

The CR chondrites have amongst the lowest matrix-normalized SiC abundances, and largest volatile element fractionations, reported in the carbonaceous chondrites [5]. However, they contain the most primitive IOM of any chondrite class [6-7], which has experienced peak temperatures of <300°C [8]. These low temperatures could not have affected the SiC grains or their noble gas concentrations, indicating that either the IOM escaped heating (implying that it is not presolar) or SiC was degassed/destroyed at low temperatures, perhaps during parent body processing [3]. Thus, in order to resolve this contradiction, it is necessary to determine SiC abundances independently of noble gases. Ion imaging of SiC grains is a direct technique that has been shown to successfully identify presolar SiC grains amongst others.

Samples: IOM separates from primitive CR chondrites GRO 95577 (CR1), Renazzo (CR2), Al Rais (CR2), GRA 95229 (CR2), EET 92042 (CR2), MET 00426 (CR2), and new Antarctic find RBT 04133 (CR2) were studied, along with Murchison (CM2), ALHA 77307 (CO3.0), Acfer 094 (ung. C2), and Semarkona (LL3.0) (Table 1). The IOM was prepared using CsF-HF (1.6-1.7 g/cc and pH 5-7) [7] with the exception of Murchison I (prepared by HF-HCl, chromic and perchloric acid demineralization [9]) and Murchison III and Renazzo (prepared by a new technique based on HF-HCl demineralisation [10]). We will compare all Murchison residues to determine whether variations in preparation methods affect SiC abundances, and to ensure Renazzo can be meaningfully compared to the other CRs.

Experimental: Ion images were obtained with the Cameca NanoSIMS 50L at the Open University. Data were processed and analysed using L'IMAGE software (Nittler, unpub.). For a detailed description of how anomalous grains are identified and how abundances are calculated see [1].

Results: *Murchison.* Table 1 shows that the presolar SiC abundances calculated here for the three different Murchison residues are comparable. This assures us that results obtained from residues prepared by different techniques (i.e. Renazzo) can be meaningfully compared, and that no method preferentially preserves/destroys SiC grains.

CRs. The presolar SiC abundances of 7 CRs (Table 1 and Fig. 1) were determined to investigate any possible variations within the group, and to compare with the single CR (Renazzo) studied by noble gases [5]. Table 1 lists the CRs in order of decreasing aqueous alteration which shows no correlation with presolar SiC abundance; indicating no significant impact of aqueous alteration. This agrees with our previous results [1].

The SiC abundances for CRs measured directly here by NanoSIMS are much higher than those determined indirectly from noble gases for Renazzo; our calculated Renazzo abundance is ~20 times larger. The variation amongst the CRs is approximately a factor of 2, although preliminary investigation of RBT 04133 suggests it will yield the lowest abundance of all CRs. Previously we had reported a high SiC abundance (120 ppm) for Al Rais (CR2), based on a very small sampled area (770 μm^2) [1]. A much larger area (4419 μm^2) of IOM from Al Rais has now been surveyed and the revised SiC abundance (39 ppm) agrees well with the other CRs. This result demonstrates that the fall/find nature of a meteorite does not affect its presolar SiC abundance and that a sufficient area of sample must be analysed in order to yield reliable data.

Other Chondrite Classes. The scope of this investigation was extended to determine the presolar SiC abundances for a limited number of particularly primitive CO, ungrouped carbonaceous chondrites and the ordinary chondrites. The CO3.0 carbonaceous chondrite ALHA 77307 gave a relatively low matrix-normalised presolar SiC abundance of 10 ppm in comparison to the CRs. However, this agrees well with the 8.8 ppm reported by [5] using noble gas analyses.

The ungrouped C2 carbonaceous chondrite Acfer 094 yielded a much higher abundance of 35 ppm, which agrees well with published data [e.g. 11].

The only OC studied here (Semarkona; an LL3.0), yields a presolar SiC abundance of 41 ppm, which is approximately two times larger than the "best estimates" from noble gas analyses [2].

Meteorite		Analysed area (μm^2)	PPM	Noble Gases
		Carbonaceous Chondrites		
CM				
Murchison I	CM2	11761	19	**21.2[1]**
II	CM2	3285	14	
III[2]	CM2	2278	14	
CR*				
GRO 95577	CR1	3239	27	
Al Rais	CR2	4419	39	
Renazzo	CR2	1915	36	**1.86[1]**
GRA 95229	CR2	4121	55	
EET 92042	CR2	3207	25	
MET 00426	CR2	3493	44	
CO				
ALHA 77307	CO3.0	7683	10	**8.8[1]**
Ungrouped				
Acfer 094	C2	1553	35	
		Ordinary Chondrites		
LL				
Semarkona	LL3.0	3232	41	**10.0 – 20.1[2]**

*Table 1. Matrix-normalised abundance of SiC in primitive chondrites studied here with NanoSIMS and by noble gas analyses [2, 5]. *CRs are listed in approximate order of decreasing aqueous alteration. [1,2]Data from [5] and [2] respectively.*

Abundances calculated by NanoSIMS should be taken as lower limits as there are a number of potential sources of bias than can lead to underestimates, including: (1) less efficient detection of grains with small isotopic anomalies, (2) decreasing detection efficiencies owing to dilution with the surrounding IOM as the grains approach the size of the ion beam, and overestimates from (3) uncertainties in the estimated grain sizes (also associated with the ion beam size).

Conclusions: Whilst the CM and CO meteorite data obtained here agree with data obtained by noble gas analyses [5], the values for CR Renazzo do not (Table 1). Our estimated abundances are closer to what would be predicted for CI-like relative abundances and are consistent with in situ observations for CRs [12, 13]. As we previously speculated, this suggests that either SiC was degassed (rather than destroyed), or only a minor gas-rich component was destroyed. The temperatures required to degas SiC are much lower (400-450°C [6]) than those required for destruction, but are still higher than the IOM experienced and are too low to explain all but the most volatile element fractionations. Similar SiC abundances in CR1s and CR2s confirm our previous conclusion that SiC was not progressively destroyed by increasing degrees of aqueous alteration [1].

It is difficult to separate noble gas release patterns into individual components and thus uncertainties in SiC abundances are introduced. Ion imaging is a direct technique, eliminating these uncertainties.

Presolar SiC abundances for new Antarctic CR2 RBT 04133 will be reported when bulk C-content data are available. We will also present the abundance of "anomalous C" [14] for all IOM samples studied here.

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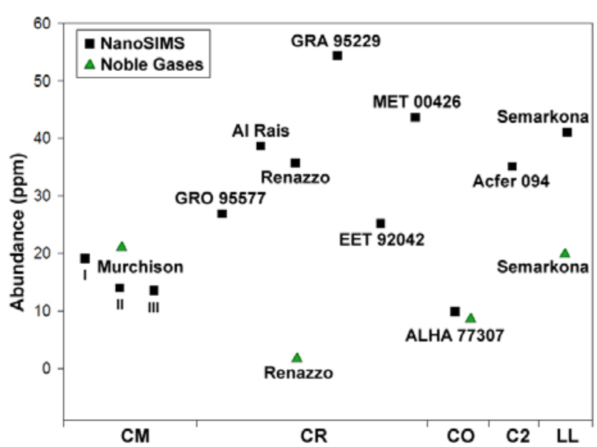

Figure 1. Matrix-normalised SiC abundances (ppm) in primitive chondrites analysed here with NanoSIMS and by noble gas analyses [2, 6]. Order (left-to-right) corresponds to order in Table 1 (top-to-bottom).