THE DISCOVERY OF AN IN SITU PRESOLAR SILICON CARBIDE IN AN ANTARCTIC MICROMETEORITE. M. Gounelle[1], S. Mostefaoui[1], A. Meibom[1], C. Engrand[2] & J. Duprat[2], [1]Laboratoire d'Étude de la Matière Extraterrestre, Muséum National d'Histoire Naturelle, 57 rue Cuvier, CP52, 75005 Paris, France (gounelle@mnhn.fr). [2]CSNSM. Bâtiment 104, 91 405 Orsay, France.

Introduction: Antarctic micrometeorites (AMMs) and Interplanetary Dust Particles (IDPs) represent the fraction of extraterrestrial matter with size < 1mm [1 , 2]. Based on chemical, mineralogical and isotopic evidence, it has been suggested that some AMMs and IDPs might originate from comets rather than from primitive asteroids [3, 4] although the distinction between these two classes of astronomical objects might be somewhat semantic [5]. While thousands of AMMs and IDPs have been studied in great detail [1, 2], the nature and abundance of presolar grains in AMMs and IDPs is poorly known. This lack of information is due to the large quantities of matter needed to isolate presolar grains using chemical techniques [6]. However, with the recent development of the NanoSIMS technology [7] it has become possible to identify and characterize the presolar component of IDPs and AMMs. In IDPs, a diversity of presolar silicates were recently discovered [e.g. 8, 9, 10]. In AMMs, eight presolar silicates were discovered by Yada et al. [11]. Here we report the first discovery of an *in situ* presolar SiC in an Antarctic micrometeorite.

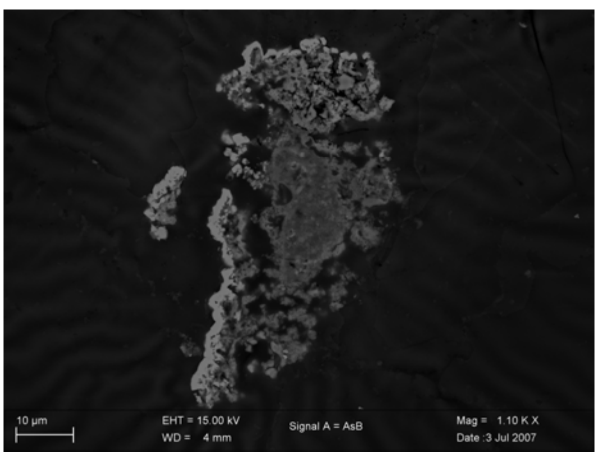

Figure 1: Back Scattered Electron image of MM7-38. The micrometeorite is 100 µm long in its longest dimension.

Methods: Micrometeorite 98-7-38 (hereafter MM7-38, see Figure 1) was collected in Terre Adélie (Antarctica) at Cap Prudhomme on February 6,1994 by Michel Maurette [12]. It was fragmented and embedded in epoxy (EMBED 812). A SiC mineral was discovered serendipitously by Scanning Electron Microscopy and Energy Dispersive X-Ray analysis examination (Figure 2). Carbon and nitrogen isotopic compositions of this SiC particle were analyzed with the NanoSIMS 50 at MNHN. A focused Cs^+ ion beam (~100nm) of ~1pA was rastered over an area of 20x20 μm^2 on the sample surface. Negative secondary ions of ^{12}C, ^{13}C, $^{12}C^{14}N$ and $^{12}C^{15}N$ were simultaneously measured in multicollection and 256x256 pixel images (a sequence of 100 plans integrated over 9 hours and 6 minutes with a counting time of 5000µs/pixel) were acquired (Figures 3 and 4). The mass resolving power was set to 6000; sufficient to resolve potential interferences. A beam of electrons was supplied to the sputtered surface during analysis in order to compensate for positive charge deposition. Isotopic ratios were obtained by the normalization of the measured ratios to a terrestrial charcoal standard with known C and N isotopic compositions.

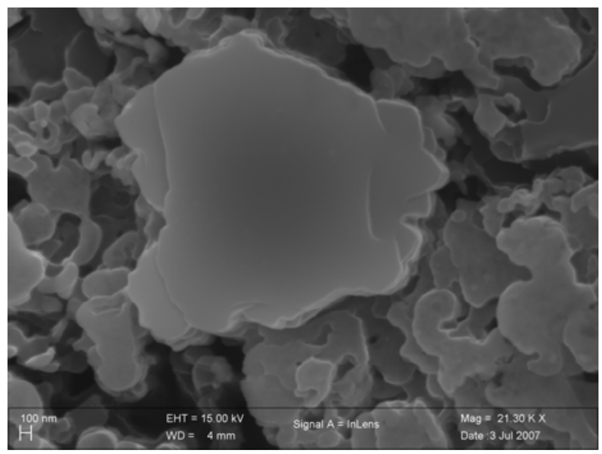

Figure 2: Secondary Electron image of the SiC grain in MM7-38. Its dimension is ~1 µm.

Results and discussion: MM7-38 is a fine-grained micrometeorite made of a silicate-rich matrix and rimmed by magnetite formed during atmospheric entry. The SiC grain belongs to the matrix, with no clear petrographic relationship with the surrounding minerals (Figure 2). The carbon and nitrogen isotopic compositions of the SiC grain found in MM7-38 are respectively $^{12}C/^{13}C = 59 \pm 1$ and $^{14}N/^{15}N = 363 \pm 11$ (errors are 1 σ, see isotopic images in Figures 3 and 4).

This is the first unambiguous identification of a presolar SiC grain in an AMM or an IDP. Yada et al. [11] reported a *possible* presolar SiC grain in an Antarctic micrometeorite collected by a Japanese field party [13]. It is not surprising that our SiC grain was found in a fine-grained AMM, which represent the less thermally altered AMMs [1].

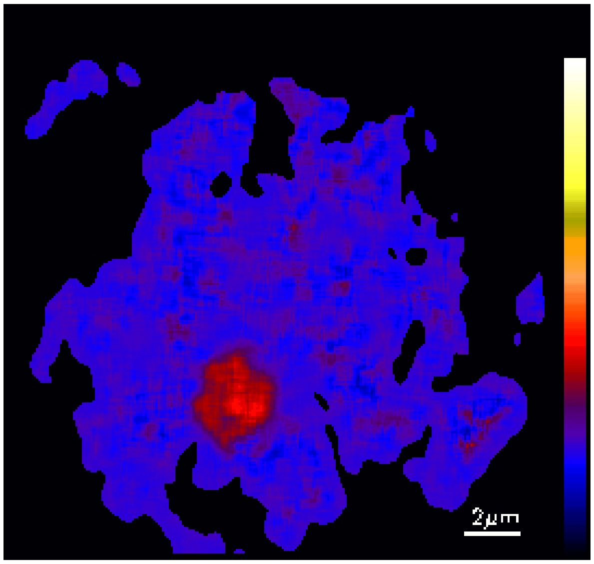

Figure 3: Map of the $^{13}C^-/^{12}C^-$ ratio in a portion of MM7-38. The blue colour indicates normal, essentially terrestrial $^{13}C/^{12}C$ ratio. The anomalous SiC grain, which is depleted in ^{12}C relative to the average micrometeorite, is clearly visible as a red object.

The SiC grain found in MM7-38 plot in the field of the main stream population of presolar SiC grains [14]. It probably formed in a C-rich asymptotic giant branch star [15]. Silicon and magnesium isotopes measurements will be made in a near future.

Only very few presolar SiC grains were discovered *in situ* [16]. Compared to the grains found by [16] in the carbonaceous chondrites (CCs) Cold Bokkeveld and Murchison [16], the SiC grain from MM7-38 looks very fresh (no foliation, cracks or fissures). It might have preserved its original crystallography, which will be measured by X-ray synchrotron.

From this one occurrence, the abundance of SiC in micrometeorite MM7-38 is estimated at ~0.1 %, which is comparable to the abundance of presolar silicates in the cluster IDP L2054 [8] and compatible with the upper limit of a few ppm for the abundance of SiC in the whole population of AMMs [17].

Contrary to what was generally thought [e.g. 17], a high abundance of presolar grains such as the one found in MM7-38 is not indicative of a cometary origin. The only *bona fide* cometary samples studied in the laboratory, i.e. the dust brought back to Earth by the Stardust mission [18], are characterized by a low abundance of presolar grains [19]. The finding of a presolar SiC in an AMM, with a composition similar to the vast majority of presolar silicon carbides in carbonaceous chondrites, strengthens the link between AMMs and carbonaceous chondrites but does not help resolve the origin (asteroidal vs cometary) of micrometeorites.

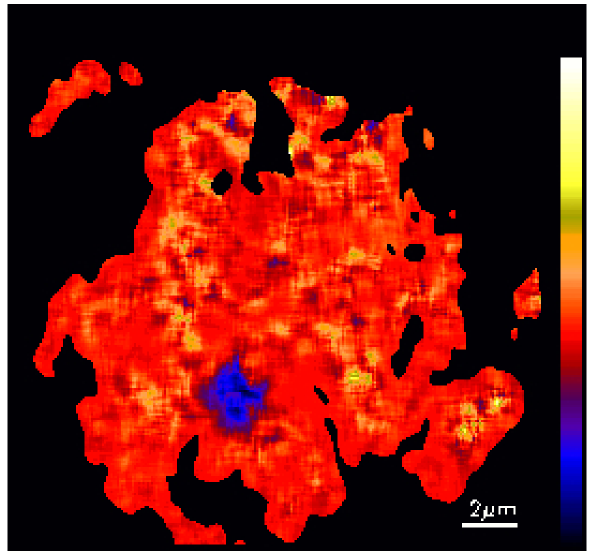

Figure 4: Map of the $^{12}C^{15}N^-/^{12}C^{14}N^-$ of a portion of MM7-38. The anomalous SiC grain, which is enriched in ^{14}N relative to the average micrometeorite, is clearly visible as a blue object.

References: [1] C. Engrand and M. Maurette, *MAPS* 33 (1998) 565-580. [2] F.J.M. Rietmeijer, in: Planetary materials, J.J. Papike, Ed. 36, Mineralogical Society of America, Washington D.C., 1998, pp. 2.1-2.94. [3] S. Messenger, *Nature* 404 (2000) 968-971. [4] M. Maurette, *Orig. Life Evol. Biosphere* **28** (1998) 385-412. [5] M. Gounelle, et al., in: The Kuiper belt, Arizona University Press, Tucson, 2008, In press. [6] E. Zinner, et al., *Nature* 330 (1987) 730-732. [7] G. Slodzian, et al., *Appl. Surf. Sci.* 203-204 (2003) 798-801. [8] A.N. Nguyen, et al., *LPSC* 38 (2007) #2332. [9] S. Messenger, et al., *Science* 309 (2005) 737-741. [10] C. Floss, et al., *GCA* 70 (2006) 2371-2399. [11] T. Yada, et al., *LPSC* 37 (2006) #1740. [12] M. Maurette, et al., in: Analysis of Interplanetary Dust, AIP Conf. Proc., M.E. Zolensky, T.L. Wilson, et al., Eds. 310, American Institute of Physics, Houston, 1994, pp. 277-289. [13] T. Yada and H. Kojima, *AMR* 13 (2000) 9-18. [14] P. Hoppe and U. Ott, in: Astrophysical implications of the laboratory study of presolar materials, T.J. Bernatowicz and E. Zinner, Eds., Saint Louis, 1997, pp. 27-58. [15] D.D. Clayton and L.R. Nittler, *ARAA* 42 (2004) 39-78. [16] C.M.O.D. Alexander, et al., *Nature* 348 (1990) 715-717. [17] R. Strebel, et al., *MAPS* 33 (Supp) (1998) A151. [18] D.E. Brownlee, et al., *Science* 314 (2006) 1711-1716. [19] K.D. McKeegan, et al., *Science* 314 (2006) 1724-1728.