

**CHARACTERIZATION OF THE ORGANIC MATTER AND HYDRATION STATE OF A SERIES OF ANTARCTIC MICROMETEORITES.** M. Battandier<sup>\*1</sup>, L. Bonal<sup>1</sup>, E. Quirico<sup>1</sup>, P. Beck<sup>1</sup>, C. Engrand<sup>2</sup> and J. Duprat<sup>2</sup>. <sup>1</sup>Institut de Planétologie et d'Astrophysique de Grenoble (IPAG), Grenoble, France. (\*Email: [manon.battandier@obs.ujf-grenoble.fr](mailto:manon.battandier@obs.ujf-grenoble.fr)). <sup>2</sup>CSNSM Université Paris-Sud, Orsay, France.

**Introduction:** Micrometeorites are extraterrestrial micrometric particles that survived to the atmospheric entry. Being the dominant contribution of extraterrestrial matter on Earth [1], they complete the sampling of small bodies of the Solar System represented by meteorites, Interplanetary Dust Particles and samples returned by space missions. Here, we report on the analysis of a series of Antarctic micrometeorites (AMMs) from the Concordia collection [2].

The present work is focused on the organic matter and hydration state of the AMMs in comparison to primitive chondrites, through combined Infrared (IR) and Raman spectroscopic characterizations. Our objective is to have a better appraisal of compositional variability across cosmomaterials.

**Sample preparation and analytical conditions:** We worked on a series of 53 AMMs. They were classified in different textural types based on SEM images, according to [3] and [4]. This classification reflects their heating during atmospheric entry. Until now, we have mostly focused on 4 AMMs: 2 fine-grained (Fg) particles named 07-19-38 and 07-13-11, 1 scoriaceous (Sc) particle named 07-07-16 and 1 intermediate particle (fine-grained-scoriaceous, Fg-Sc) named 07-19-37. Fg AMMs did not experienced significant heating through the atmospheric entry, in contrast to Sc and Fg-Sc AMMs that are partially melted [4].

AMMs were stored on individual glass slides in a desiccator. To allow for the acquisition of IR spectra with a good signal-to-noise ratio, each of them were transferred and pressed on a diamond window. This sample preparation is also compatible with Raman micro-spectroscopy. Sample preparation was done under an ISO 5 laminar hood, in an ISO 7 clean room. AMMs handling was performed manually with a needle under a binocular microscope. A specifically designed press was used to crush the samples between two diamond windows. The size of the considered AMMs typically ranged between 30 and 100  $\mu\text{m}$ .

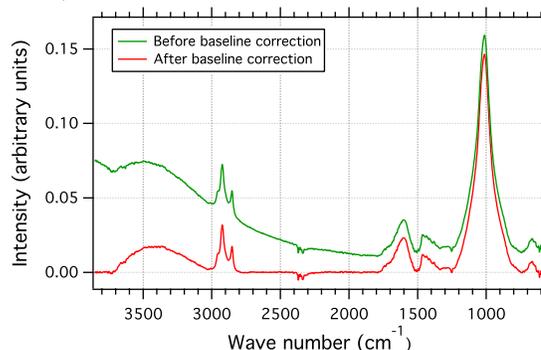
IR spectra were obtained with a BRUKER HYPERION 3000 infrared microscope (IPAG, France). The IR beam was focused with a 15x objective and the spectral range extended between 4000 and 500  $\text{cm}^{-1}$ . IR spectra were collected at 4  $\text{cm}^{-1}$  spectral resolution. The sample were loaded in a cell allowing for the spectral acquisition under vacuum ( $P=10^{-6}$

mbar) and gentle heating (here  $T=80^\circ\text{C}$ ) to eliminate terrestrial water absorbed by the AMMs [5].

Raman spectra of some unpressed AMMs were acquired to complete the previous work by [6]. The acquisition of Raman maps of the four pressed AMMs, to reveal potential structural heterogeneity of the polyaromatic structure, is now under progress.

AMMs as a whole might be related to CR and CM carbonaceous chondrites [e.g.,7]. Therefore, in order to compare our results, we also acquired IR and Raman spectra of QUE99177 (CR) and Murchison (CM) chondrites.

IR spectra were analyzed with IGOR Pro WaveMetrics software. A spline baseline correction was performed (Fig. 1) and spectra were all normalized to the intensity of the silicate Si-O stretching band (at  $\sim 1000 \text{ cm}^{-1}$ ).



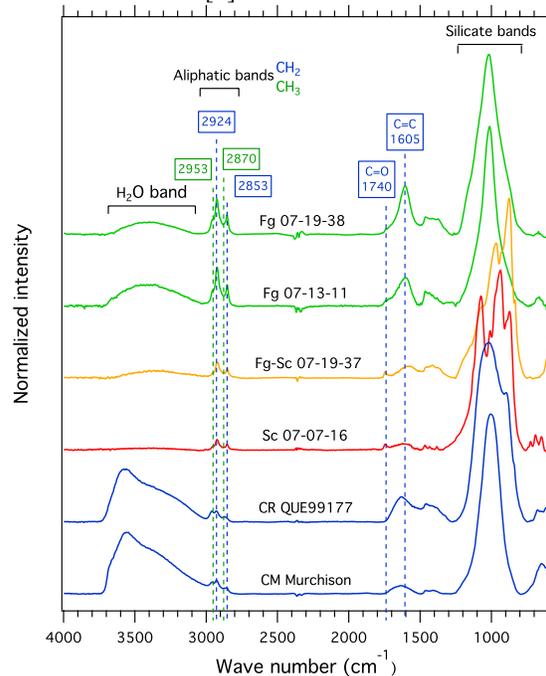
**Figure 1: IR spectra of Fg 07-13-11 AMM before and after baseline correction.**

**Results:** IR spectra obtained for AMMs and carbonaceous chondrites, corrected and normalized, are shown in Fig. 2.

*Organic matter:* The presence of aliphatic organic matter ( $\text{CH}_2$  and  $\text{CH}_3$ ) is characterized by bands around 2900  $\text{cm}^{-1}$ . The band centered at  $\sim 1600 \text{ cm}^{-1}$  suggests the presence of the C=C aromatic bond and the peak around 1740  $\text{cm}^{-1}$  may reflect the presence of C=O.

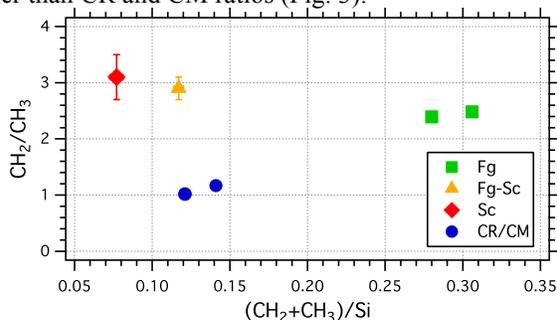
Normalized IR spectra of the 4 considered AMMs show that the  $\text{CH}_2$  and  $\text{CH}_3$  stretching bands are more intense in unmelted particles (Fg AMMs) than in partially melted one (Sc and Fg-Sc AMMs) (Figs. 2 and 3). C=C band also appears to be more intense in the Fg AMMs compared to the partially melted AMMs (Fig. 2). The amount of organic matter (relative to silicates) appears to be higher in the unmelted particles. We de-

terminated the  $\text{CH}_2/\text{CH}_3$  ratios from the band intensities for each sample (Fig. 3). The four considered AMMs are characterized by similar  $\text{CH}_2/\text{CH}_3$  ratios, also comparable to that in IDPs [8].



**Figure 2: Normalized IR spectra of the 4 AMMs and 2 carbonaceous chondrites considered, with main absorption bands.**

Comparison with CR and CM spectra (Fig. 2) shows that the aliphatic bands in carbonaceous chondrites are much less intense than in the fine-grained AMMs. Moreover, the AMMs  $\text{CH}_2/\text{CH}_3$  ratios are larger than CR and CM ratios (Fig. 3).



**Figure 3:  $\text{CH}_2/\text{CH}_3$  ratios versus normalized aliphatic peak intensities ( $\text{CH}_2 + \text{CH}_3$ ). These numbers were all retrieved from normalized IR spectra (see text).**

Raman spectra of bulk AMMs confirmed the results obtained by [6]: differences in the polyaromatic structure between AMMs and chondrites of types 1, 2 and 3 and also across the different textural types of AMMs. Raman maps acquired on pressed AMMs

seem to evidence a structural heterogeneity within the Fg-Sc AMM.

**Mineralogy and hydration state:** Each considered AMM exhibits the presence of the silicate Si-O stretching band around  $1000 \text{ cm}^{-1}$  (Fig. 2). For the two Fg AMMs, the IR band is comparable, but not similar, to that in CR and CM chondrites. The wide band between  $3000$  and  $3700 \text{ cm}^{-1}$  reveals the presence of structural water (as adsorbed terrestrial water was released thanks to the heating and vacuum) (Fig.2). This band is present in the two Fg AMMs and in the carbonaceous chondrites. It lacks in the spectra of partially melted AMMs. The two Fg AMMs appear to have a hydrated mineralogy as carbonaceous chondrites. In the two partially melted AMMs, the shape and position of the silicate band point to the presence of olivine in the Fg-Sc AMM and pyroxene in the Sc AMM. So the two partially melted AMMs have a dominantly anhydrous mineralogy, either indigenous or resulting from dehydration during atmospheric entry.

**Discussion:** IR results reveal some variability in terms of mineralogy and aliphatic content across the 4 considered AMMs. The differences do not seem to be only controlled by the extent of heating through atmospheric entry. The hydrated mineralogy observed for the two Fg AMMs shows that they have experienced some aqueous alteration on their parent body. Moreover, the unmelted AMMs are richer in organic matter than the partially melted ones. These differences in terms of mineralogy and organic matter might suggest that the considered AMMs sampled either a quite heterogeneous or different parent bodies.

The two Fg AMMs have experienced some aqueous alteration, similarly to CR and CM chondrites. However, these AMMs appear to be clearly enriched in organic matter compared to the chondrites. Moreover, their  $\text{CH}_2/\text{CH}_3$  ratios are significantly different. These differences cannot be easily explained as the consequences of thermal heating through the atmospheric entry nor by various intensity of aqueous alteration. This might suggest that the considered AMMs sampled parent bodies different from CR and CM chondrites.

**References:** [1] Love S. G. and Brownlee D. E. (1993) *Science*, 262, 550. [2] Duprat J. et al. (2007) *Advances in Space Research*, 39, 605. [3] Genge M. J. et al. (2008) *MAPS*, 43, 497. [4] Dobrica E. (2010) *PhD dissertation*. [5] Beck P. et al. (2010) *GCA*, 74, 4881. [6] Dobrica E. et al. (2011) *MAPS*, 46, 1363. [7] Engrand C. and Maurette M. (1998) *MAPS*, 33, 565. [8] Flynn G. J. et al. (2003) *GCA*, 67, 4791.

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