NON DESTRUCTIVE IR MICRO-IMAGING OF THE PARIS METEORITE

Z. Dionnet[1], A. Aleon-Toppani[1] , F. Borondics[2], R. Brunetto[1], Z. Djouadi[1], D. Troadec[3], [1]Institut d'Astrophysique Spatiale, CNRS, Université Paris-Saclay, France, Email: zdionnet@ias.u-psud.fr, [2] Synchrotron SOLEIL, France, [3] Institut d'Electronique, de Microélectronique et de Nanotechnologie

Introduction: Primitive extraterrestrial materials (meteorites, IDPs) are characterized by a large mineralogical and compositional heterogeneity at different scales (from nm to mm) [1], which witnesses the complexity of the pre-accretional (solar nebula) and post-accretional (parent bodies) processes [2]. This heterogeneity has been observed by different techniques such as micro infrared (IR) spectroscopy mapping but with a limited resolution (> 5 µm). IR spectroscopy is a powerful tool as it is (a) totally non-destructive, (b) able to characterize the molecular vibrations, and in particular to access both to the mineral and carbonaceous phases and (c) comparable to astronomical observations of primitive Solar System small bodies (asteroids, comets, TNOs) [3] and ISM dust [5]. With the development of a new detector (Focal Plan Array (FPA)), IR mapping with high spatial resolution and IR tomography is now possible. Here, we report the results of high-resolution Fourier Transform IR spectral imaging experiments at micron scale using FPA and synchrotron radiation of the Paris meteorite (CM chondrite [4]). The FTIR micro-analyses were performed in the SMIS beamline, SOLEIL French synchrotron, with a FPA detector and a globar source.

Sample preparation: We studied two grains of the Paris meteorite. The first preparation was obtained by crushing the meteorite sample between diamond windows. A second grain (size ~20 µm) of the Paris meteorite was prepared using a new method by welding it on a needle using a Focused Ion Beam (FIB) microscope. The main advantage of this preparation is to keep the 3D structure of the sample.

Results: We measured the spatial distribution of chemical/mineralogical components (organic materials, anhydrous silicates, hydrated silicates, carbonates) of the Paris meteorite and the correlation between the organic and silicate phases down to a scale of ~1 µm. We also studied the heterogeneity of the organic matter and especially the variation of the ratio CH_2/CH_3. Mapping using FPA detectors is powerful as it allows a high spatial resolution in a very limited acquisition time (less than 20 min for a grain of 50x40 µm vs more than 200 min with a "classical" mapping).

Raman micro-spectroscopy showed that the meteorite particle welded on the needle had very little surface carbon contamination (localized in the welding spot) induced by the FIB preparation. This new sample preparation, along with the coupling of FPA and synchrotron radiation, will allow to perform non-destructive IR micro-tomography on extraterrestrial samples.

Acknowledgements : This work is supported by the "IDI 2015" project funded by the IDEX Paris-Saclay, ANR-11-IDEX-0003-02 and funded by the French national program "Programme National de Planetologie" (PNP). The micro-spectroscopy activities are supported by grants from Région Ile-de-France (DIM-ACAV) and SOLEIL. We thank D. Baklouti, L. d'Hendecourt, and C. Sandt for fruitful discussions. We are grateful to M. Thoury for support at the IPANEMA platform, and M. Kansiz for useful suggestions.

References: [1] Rietmeijer F.J.M. (1998) Reviews in Mineralogy, Mineralogical Society of America, Washington, vol. 36, 95pp. (Chapter 2). [2] Alexander C.M.O'D., Boss A.P. (2007) Protostars Planets V, 801–813. [3] Brunetto R. et al. (2011) Icarus 212, 896–910. [4] Hewins R. et al (2014) Geochimica et Cosmochimica Acta 124, 190-222. [5] Merouane S., Djouadi Z. et al (2012) The Astrophysical Journal, 756:154.