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"Paris" meteorite analysis using cluster and particle impacts

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"Paris" meteorite is a fragment from a primitive planetesimal, asteroid or comet. A piece of this meteorite is provided by the Museum National d'Histoire Naturelle in Paris and classified as a carbonaceous chondrite CM type belonging to the undifferentiated family [1, 2]. This kind of meteorites keeps the memory of their primary history and contains carbonaceous matter which permits to understand the prebiotic chemistry.

In this paper we present a new analysis approach combining multi complementary techniques elemental and structural ones. This study is performed on a 500*500 μm^2 of the Paris meteorite using mass spectrometry ToF-SIMS coupled to imaging, micro Infra Red, micro Raman and Ion Beam Analysis (Particle Induced X-ray Emission "PIXE", micro PIXE, Rutherford Backscattering "RBS").

The ToF-SIMS analyzes are performed using bismuth (Bi^+, Bi_3^+ at 25 keV, 1.3 pA) and argon Ar_{1000} (10keV) beams delivered by an ION-TOFV of the Lebanese Atomic Energy Commission (CNRSL-LAEC). PIXE and RBS are performed using a 3 MeV proton beam delivered by a 1.7 MV tandem accelerator of LAEC while the μ-PIXE (3MeV proton) experiments are performed at the AGLAE (Accelerateur Grand Louvre d'Analyse Elementaire). The micro IR Spectra (1.5-15μm) are registered at the Soleil SMIS (Spectroscopy and Microscopy in the Infrared using Synchrotron) beam line using a NicPlan microscope, coupled to a FTIR spectrometer operating in confocal reflection. Raman micro-spectroscopy uses a DXR Raman spectrometer from Thermo Fisher with a 532 nm exciting laser radiation.

In this paper, we shall discuss the results of the "Paris" fragment analysis obtained by the different complementary techniques. ToF-SIMS permits to identify and localize different elements, minerals and different types of organic compounds (CN-CNO and CxHy). An additional analysis in depth using the argon cluster is done in order to localize, in depth, the different components and especially the organic ones. While micro-IR and micro Raman permit the identification of different mineral compounds (Forsterite, enstatite, calcium sulfate and carbonate) and aromatic carbon ones. Additionally, we used the Ion Beam Analysis (PIXE and RBS) to determine the elemental composition and μ-PIXE to determine the local composition of different minerals like olivine and pyroxene crystal families.

In this presentation, we shall discuss the "Paris" meteorite results obtained with traditional astrophysical methods (μ-IR, μ-Raman) with an emphasis on the ToF-SIMS measurements completed by the IBA results. We conclude the presentation by the advantages and the limitations of these methods.

[1] Bourot-Denise, M., et al.: Paris: the slightly altered, slightly metamorphosed CM that bridges the gap between CMs and COs,41st LPSC, 2010..

[2] M. Noun, M. Roumie, T. Calligaro, B. Nsouli, R. Brunetto, D. Baklouti, L. d'Hendecourt, S. Della-Negra, On the Characterization of the "Paris" Meteorite Using PIXE, RBS and Micro PIXE, accepted in Nucl. Instr.and Meth. in Phys. Res. B (2013)