TOF-SIMS CHARACTERIZATION OF ORGANIC MATTER IN THE MINERAL CONTEXT OF AQUEOUS ALTERATION OF CM CHONDRITES.

Y. Arribard[1], M. Noun[2], S. Della-Negra[3], B. Doisneau[4], F. Daubisse[3], D. Jacquet[3], I. Ribaud[3], R. Brunetto[1] and D. Baklouti[1], [1]Institut d'Astrophysique Spatiale, Université Paris-Saclay, CNRS, 91405, Orsay, France (yann.arribard@universite-paris-saclay.fr), [2]Lebanese Atomic Energy Commision, NCSR, Beirut 11 -8281, Lebanon, [3]IJCLab, CNRS/IN2P3, Université Paris-Saclay, F-91406, Orsay, France, [4]IMPMC, MNHN, Sorbonne Université, CNRS, Paris, France.

Introduction: The organic content of chondrites has been widely analyzed after chemical extraction and separation into soluble [e.g. 1] and insoluble phases [e.g. 2, 3, 4] but much less studied "*in situ",* i.e. directly in the meteorite bulk, keeping intact its mineral environment [e.g. 5, 6]. In this study, we present a Time of Flight Secondary Ion Mass Spectrometry (TOF-SIMS) analysis of samples of 2 differently altered CM chondrites. TOF-SIMS gives information about the composition and the structure of the organic and mineral compounds detected on the sample surface analyzed. It has already been successfully used to study the organic content of extraterrestrial samples [7,6,8]. Our purpose is more precisely, to study the variations in the chemical structures and localizations of the organic content depending on the aqueous alteration context of each CM sample measured, in order to better understand the different steps of hydrothermal processes that affected the parent asteroids.

Materials and methods: We analyzed freshly cut millimetric slices of 2 CM chondrites (see [9] for the preparation protocol): Cold Bokkeveld (CM2.2 [10]) and Paris (CM2.7-2.9 [11,12]). The slices, previously analyzed by IR reflectance hyperspectral imaging and Raman spectroscopy [9], were measured by TOF-SIMS 2D imaging with an ION-TOF V mass spectrometer, following a protocol optimized in a previous study [6]. The measurements were carried out on areas of 500x500 µm² with a spatial resolution of 2 µm per pixel. After a cleaning with argon clusters ($Ar_{1300\text{-}1900}$), the surfaces were analyzed by a Bi_3^+ cluster beam at 25 keV. An ordinary chondrite, Tuxtuac (LL5 [13]), was also prepared and analyzed in the same conditions and used as a control sample.

Results and discussion: We obtained maps displaying the distribution of different types of organic compounds and fragments on the chondrite samples measured. These maps strongly confirm the IR and Raman preliminary analysis [9]. They show that the organic species are present throughout the matrix and the chondrules of Cold Bokkeveld, except in carbonate and sulfate-rich regions, whereas they are mostly concentrated in the phyllosilicate-rich matrix, generally next to chondrules, in Paris samples. Comparison of the samples' mass spectra also provides information about the variations in the unsaturation degree or carbon chain length. Indeed, we found that Cold Bokkeveld exhibits a lower average H/C ratio than Paris for hydrocarbon fragments containing at least 3 carbons. This result implies an increase of the unsaturation degree with increasing alteration. It is consistent with the trend observed by Alexander et al. [14] for insoluble organic matter extracted from differently altered regions of Tagish Lake (C2), and suggests that organic compounds are affected by aromatization and/or crosslinking during aqueous alteration. Based also on our study of heteroatom-containing fragments, we will discuss the evolution stages undergone by organic matter during hydrothermal alteration of CMs.

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