

**EXPERIMENTAL ALTERATION OF INSOLUBLE ORGANIC MATTER OF THE PARIS METEORITE.**

B. Laurent<sup>1</sup>, M. Holin<sup>1</sup>, O. Beyssac<sup>1</sup>, R. Brunetto<sup>2</sup>, A. Brunelle<sup>3</sup>, C. Bouvier<sup>3</sup> and L. Remusat<sup>1</sup>, <sup>1</sup> IMPMC- Sorbonne Univ., MNHN, CNRS UMR 7590, 75005 Paris, France, <sup>2</sup>Institut d'Astrophysique Spatiale- Université Paris-Saclay, CNRS, 91405, Orsay, France, <sup>3</sup>LAMS- Sorbonne Univ., CNRS UMR 8220, 75005, Paris, France.

**Introduction:** Recent sample-return missions (Hayabusa 2 and Osiris Rex) have initiated a new era in the understanding of organic delivery on terrestrial planets [1,2]. While the ex-situ analysis of the new asteroidal material should provide clues regarding carbon chemistry dating back from the planetary formation, carbonaceous chondrites as the remnant fragments of distant C-type asteroids [3] offer valuable targets to understand the effects of asteroidal processes on organic materials. CMs have been preferred targets for organic matter investigations and are hosts of a diverse suite of organic compounds [4]. Most of the carbon resides in a form of insoluble organic matter, forming small aromatic units linked by short highly crosslinked aliphatic chains [5,6]. This IOM is expected to have recorded and preserved the signatures of preaccretionary events that occurred in the protosolar nebula and the parent molecular cloud [7].

As evidenced by the replacement of anhydrous silicates by secondary minerals, oxidation of metal grains and sulphides [8], CM parent body has experienced significant aqueous alteration. It remains unclear how fluid circulations have affected the organic precursors in asteroidal conditions; structural and isotopic effects of the asteroidal evolution can be approached through hydrothermal degradation experiments.

**Results:** The IOM [9] from weakly altered Paris (CM2.7) was subjected to aqueous alteration in asteroidal conditions at 150°C in pure water. After 49 days of experimental alteration, the IOM was characterized by FTIR, ToF SIMS, Raman spectroscopy to determine microstructural and molecular evolution and by NanoSIMS to estimate the hydrogen and nitrogen isotope evolution. The results, compared to newly recovered altered CM2.2 Aguas Zarcas [10] and CM2.0 Mukundpura [11], reveal a series of comparable structural features: increase of aromatic/aliphatic carbon, decrease of CH<sub>2</sub>/CH<sub>3</sub> ratio and a loss of carbonyl groups. However, Raman indicates that the structural differences observed after experiment suggest that OM from highly altered CMs would not derived from a Paris-like precursor, where thermal effects would prevail over aqueous oxidation.

Surprisingly, these molecular and structural evolutions do not echo with significant isotope and elemental ratio evolution. D/H ratio slightly decreases upon hydrothermal treatment ( $\delta D$  from 800±20‰ to 620±50‰). More importantly, the D-rich hot spots usually observed in CM IOMs [7] remain and share similar distribution with the untreated IOM: modal value around 2200 ‰, max 6200‰ for treated IOM, 8500‰ for untreated one. A similar observation can be made for  $\delta^{15}N$ , N/C, O/C and S/C ratios determined by NanoSIMS.

**Discussion:** Our experiment confirms several hypotheses about the influence of aqueous alteration on the IOM of carbonaceous chondrites, including the loss of aliphatic carbon and carbonyl groups and the increase of aromatic carbon contribution. In the meantime, aliphatic branching increases. Nevertheless, our experiment does not reproduce the loss of heavy isotopes of H and N that is often assumed to result from aqueous alteration [12]. Molecular and isotope evolution, assumed to explain the differences between IOMs in poorly altered and highly altered chondrite, appears decoupled.

We conclude that none of the CM chondrite currently hosts the IOM precursor of the CM parent body, which has reacted and lost some of its features even in the poorly altered Paris meteorite. The observed differences between poorly and highly altered CMs can potentially result from the initial proportion of ice incorporated in the asteroidal stage, that in turn would influence the maximum peak temperature and oxidation state of the hydrothermal fluid. Nevertheless, the isotope features (enrichments in heavy isotopes of H and N, occurrence of D and <sup>15</sup>N-rich hotspots) appear slightly affected. This implies that they relate to preaccretionary episodes, whether in the protosolar nebula or in the parent molecular cloud.

**References:** [1] Watanabe S.I. et al. (2017) *Earth and Planetary Science Letters* 458: 273-281. [2] Lauretta D. S et al. (2017) *Space Science Reviews* 212:925-984. [3] Gaffey M.J. et al. (1983) *Meteoritics* 28:161-187. [4] Schmitt-Kopplin P. et al. (2010) *Proceedings of the National Academy of Sciences* 107:2763-2768. [5] Derenne S. and Robert F. (2010) *Meteoritics & Planetary Science* 45:1461-1475. [6] Orthous-Daunay F. R. et al. (2013) *Icarus* 223 :534-543. [7] Remusat L. et al. (2009) *The Astrophysical Journal* 698 : 2087-2092. [8] Rubin A.E. et al. (2007) *Geochimica et Cosmochimica Acta* 71 :2361-2382. [9] Vinogradoff V. et al. (2019) *Geochimica et Cosmochimica Acta* 212:234-252 [10] Martin P. M. C. & Lee M. E. (2020) *LPS LI*, Abstract #1375. [11] Rudraswami N.G et al. (2019) *Geoscience Frontiers* 10 :495-504. [12] Alexander C. M. O'D. et al. (2007) *Geochimica et Cosmochimica Acta* 71 :4380-4403.

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