



## What if the insoluble organic matter of meteorites showed unexpected molecular diversity?

Gregoire Danger, Alexander Ruf, Julien Maillard, Vassilissa Vinogradoff, Philippe Schmitt-Kopplin, Carlos Afonso, Isabelle Schmitz-Afonso, Laurent Remusat

### ► To cite this version:

Gregoire Danger, Alexander Ruf, Julien Maillard, Vassilissa Vinogradoff, Philippe Schmitt-Kopplin, et al.. What if the insoluble organic matter of meteorites showed unexpected molecular diversity?. EPSC, Europlanet, Sep 2022, Grenade, Spain. 10.5194/epsc2022-284 . hal-04295891

**HAL Id: hal-04295891**

**<https://hal.science/hal-04295891>**

Submitted on 20 Nov 2023

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# What if the insoluble organic matter of meteorites showed unexpected molecular diversity?

Grégoire Danger<sup>1,2,3</sup>, Alexander Ruf<sup>1</sup>, Julien Maillard<sup>4,5,6,7</sup>, Jasmine Hertzog<sup>8,9</sup>, Vassilissa Vinogradoff<sup>1,2</sup>, Philippe Schmitt-Kopplin<sup>8,9</sup>, Carlos Afonso<sup>4,5,6</sup>, Isabelle Schmitz-Afonso<sup>4,5,6</sup>, and Laurent Remusat<sup>10</sup>  
Germany

## Abstract

We developed a new strategy to analyze the insoluble organic matter (IOM) of meteorites. Using laser desorption ionization (LDI) coupled to a high-resolution mass spectrometer (FT-ICR-MS), we demonstrate for the first time that an important molecular diversity with low masses form these IOMs. These results complete the general view of IOM being a set of hydrophobic macromolecules.

## 1. Introduction

Carbonaceous chondrites (CCs) are fragments of primitive asteroids that are known to contain up to 6 wt.% of organic matter (OM). The insoluble organic matter (IOM) represents 75 to 95 wt.% of the total recovered organic matter. It is therefore the major organic carbon component of CCs. Its Analyses revealed that the IOM is constituted of aromatic units with aliphatic structures bridging aromatic units. Heteroatoms also compose the IOM with mostly oxygen next to nitrogen and sulfur. As a result, the IOM is schematically represented as a cross-linked structure of aromatic and aliphatic units with some heteroatoms, constituting macromolecules. Here, we used a new analytical method to analyse an IOM fraction of Paris meteorite: Laser desorption ionization (LDI) coupled to an ultra-high-resolution mass spectrometer (FT-ICR-MS) on a Paris IOM, which demonstrate that an important molecular diversity with low masses also forms IOM of meteorites.

## 2. Results

The coupling of LDI with a high-resolution mass spectrometer allows obtaining information on the molecular diversity present in this IOM. We indeed reveal new and original information on the molecular composition, diversity and aromaticity of the Paris IOM that can be related to synthesis environments during the early ages of the solar system.

An unprecedented molecular diversity (Figure 1A) is observed with a wide range of molecular family (Figure 1B).

Molecules observed present low masses with a high aromaticity and the presence of low amounts of heteroatom such as N, O and S.

The molecular cores are based on aromatic rings with various aliphatic branching depending on the molecular family.

Pure PAH are also observed, and fullerenes are observed at higher laser energy, suggesting a formation from high PAH structures that could correspond to a part of the IOM macromolecular structure.

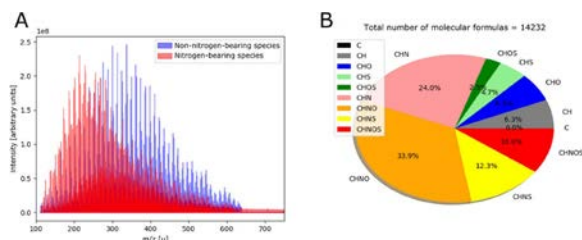


Figure 1: (A) Mass Spectrum of the Paris IOM analyzed by LDI FT-ICR-MS and (B) the repartition by the different molecular families.

## Acknowledgements

We are grateful to the meteorite collection of the Muséum National d'Histoire Naturelle in Paris for providing the sample of the Paris meteorite.

N.C. and L.R. thank the European Research Council for funding via the ERC projects PrimChem (grant agreement No. 636829) and HYDROMA (grant agreement No. 819587). This work was supported by the European Regional Development Fund (ERDF) No. HN0001343, the European Union's Horizon 2020 Research Infrastructures program (Grant Agreement 731077), the Région Normandie, and the Laboratoire d'Excellence (LabEx) SynOrg (ANR-11-LABX-0029). Access to a CNRS FTICR research infrastructure (FR3624) is gratefully

acknowledged. G.D., A.R., and L.R. thank the Agence nationale de la recherche (RAHIA\_SSOM, ANR-16-CE29-0015), the Centre National d'Etudes Spatiales from its exobiology program, and the Centre National de la Recherche Française (CNRS, "Physique et Chimie du Milieu Interstellaire" (PCMI) and "Programme National de Planétologie" (PNP) programs) for their financial support..

## References

[1] Unprecedented molecular diversity revealed in meteoritic insoluble organic matter : The Paris meteorite's case. G. Danger\*, A. Ruf, J. Maillard, J. Hertzog, V. Vinogradoff, P. Schmitt-Kopplin, C. Afonso, N. Carrasco, I. Schmitz-Afonso, L. Le Sergeant d'Hendecourt, Laurent Remusat. Planetary Science Journal, 2020, 1, 55.