



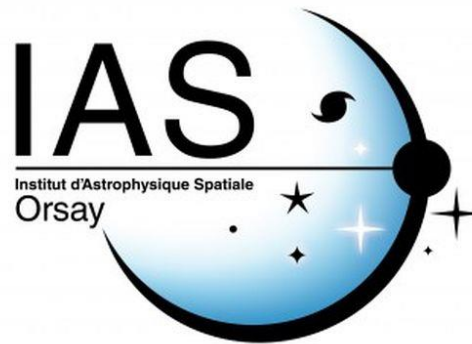
École Doctorale d'Astronomie & Astrophysique
d'Île-de-France

université
PARIS-SACLAY

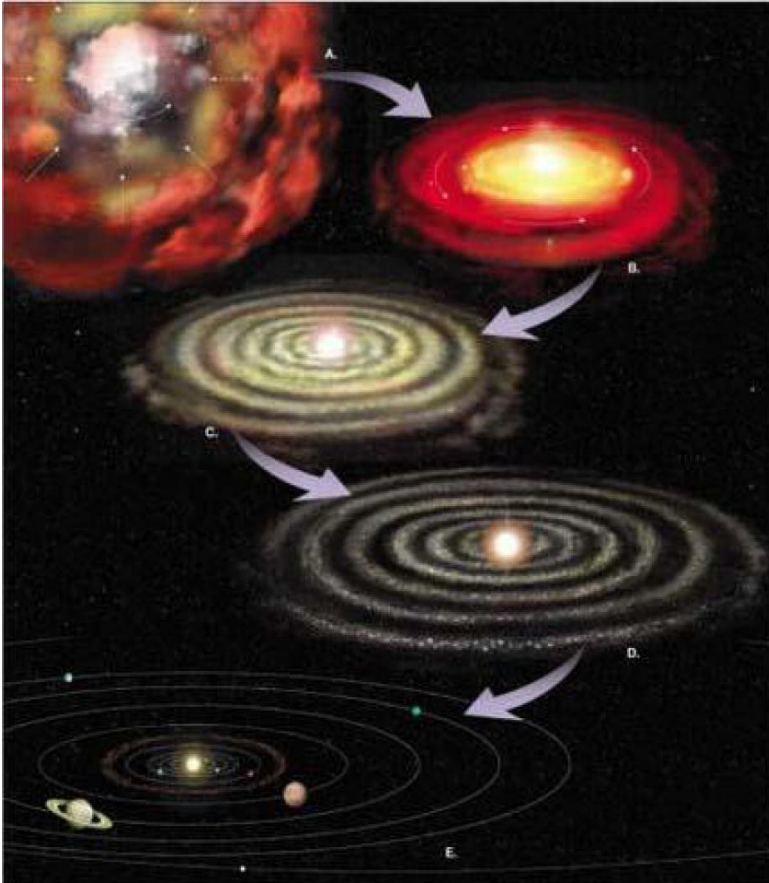
Analysis of organic matter and mineral phases in bulk chondrites by MIR Reflectance Hyperspectral Imaging

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Solar system formation



=> We focus on the residues of the formation

The different meteorites

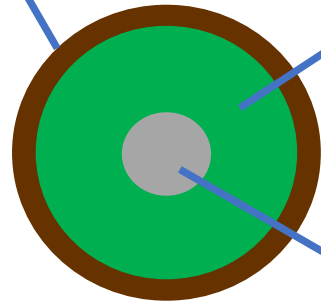
Differentiated parent bodies:

Achondrites

Stony



Stony-irons



Irons



Corps parents non différenciés :

Chondrites

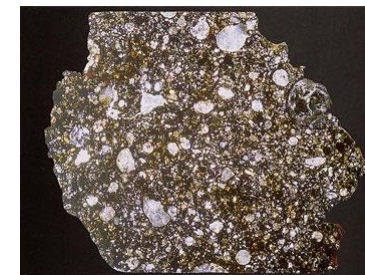
Carbonaceous



Ordinary



Enstatite



The carbonaceous chondrites

- Fusion crust(black)
- Composition : Chondrule (=spherical silicate inclusion in the matrix) (light) : mainly olivine ($(\text{Mg,Fe})_2\text{SiO}_4$) and pyroxene ($(\text{Mg,Fe})\text{SiO}_3$)
Matrix : mainly phyllosilicates (hydrated silicates) (dark)

The most interesting one for the organic matter



Météorite Paris



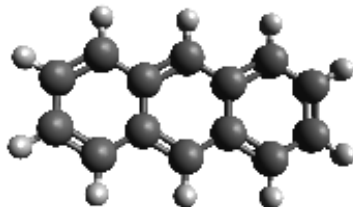
Murchison, 28/09/1969, Australie

The organic matter of chondrites

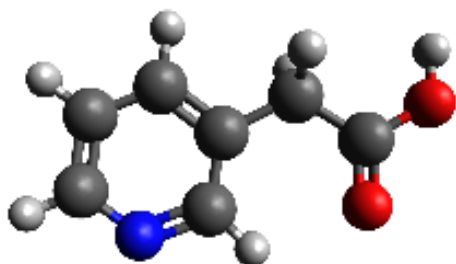
Soluble organic matter (SOM)



Amino acids



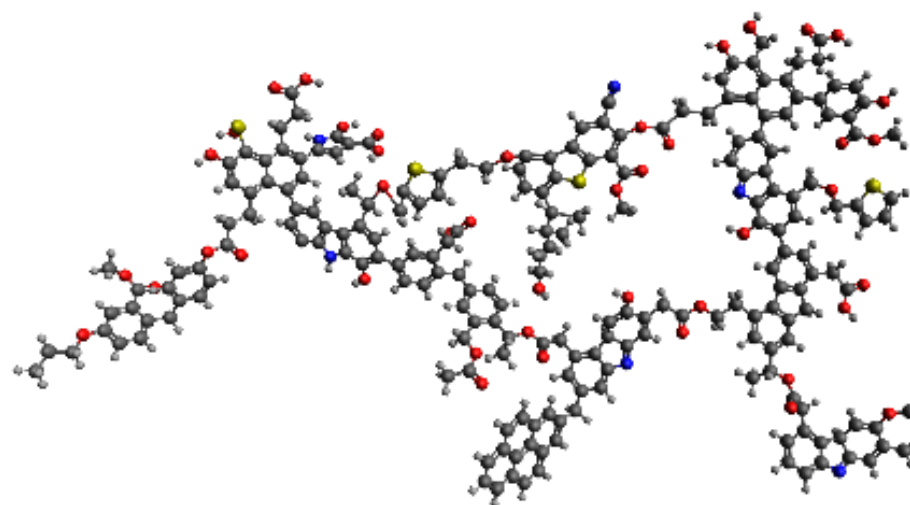
Hydrocarbons



Pyridinic acids

Insoluble organic matter (IOM)

Cross-link desordered macromolecule
(3D grid)



80%

Objectives of the thesis

Characterize the primitive extraterrestrial organic matter *in situ*

- ⇒ Understand the physico-chemical interactions between the organic and mineral phases to the micrometric scale.
- ⇒ Reconstruct the chemistry at the origin of the formation and evolution of the organic matter

Methods

TOF-SIMS mass spectrometry

- Chemical characterization of the organic and mineral matter
- Detection of organometallic molecules

complementarity

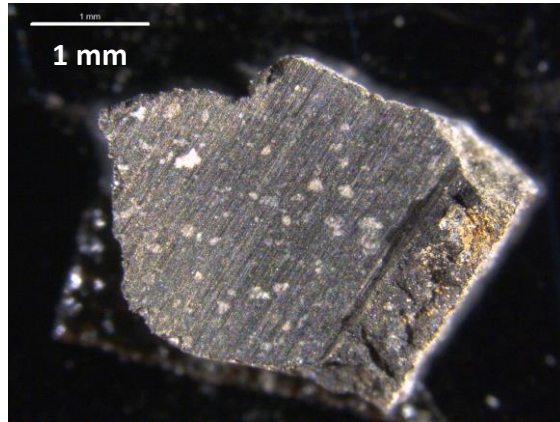


MIR reflectance hyperspectral imaging and raman spectroscopy

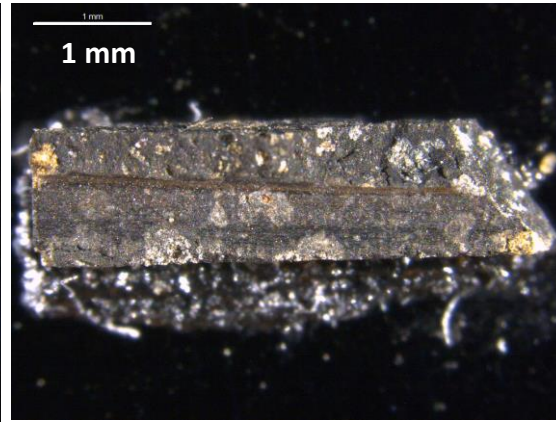
- Identification of chemical fonctions
- Characterization of hydration
- Characterization mineralogic

Study of the spatial distribution

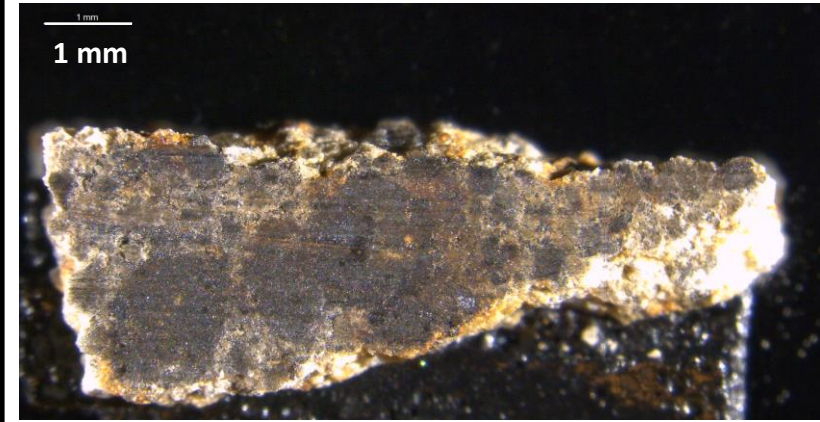
Multi-technic analysis of chondrites



Cold Bokkeveld
CM2,2



Paris
CM2,8



Tuxtuac
LL5

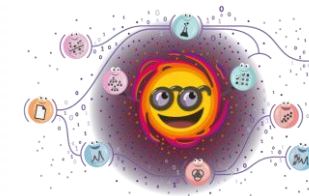
Carbonaceous chondrites

Ordinary Chondrites

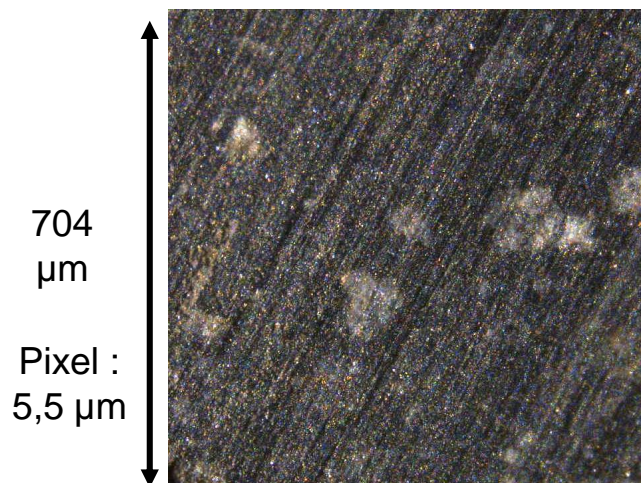
Chondrites

MIR hyperspectral imaging

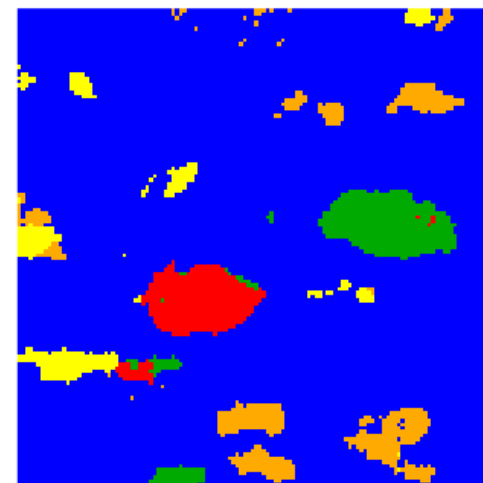
Cold Bokkeveld (CM2,2)



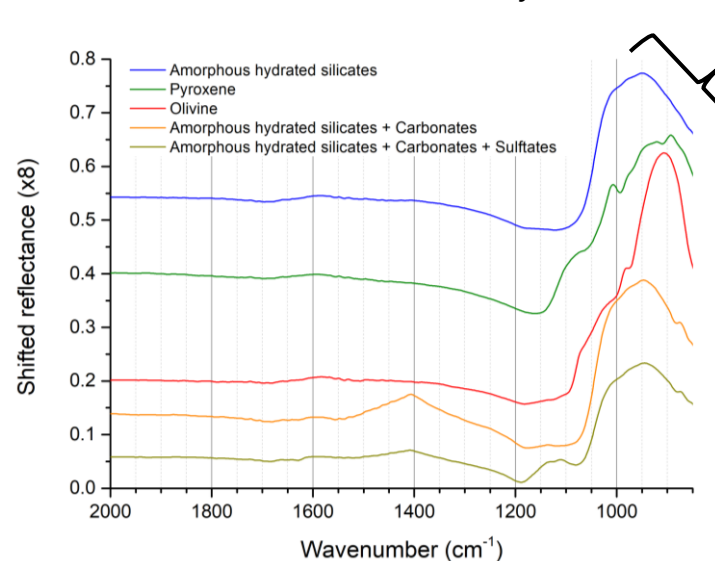
Quasar Software



Photography with a macroscope of the analyzed surface



K-mean clustering of infrared data of the analyzed surface



Si-O Stretching band

Bue : Amorphous hydrated silicates = 86,42 %

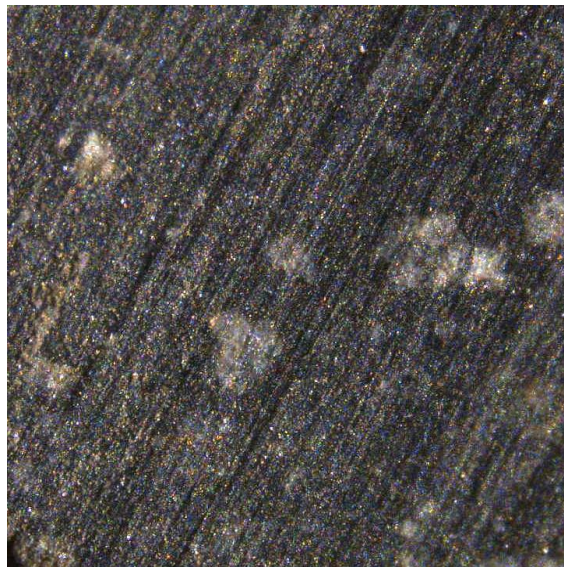
Red : Olivine = 2,99 %

Green : Pyroxène = 3,79 %

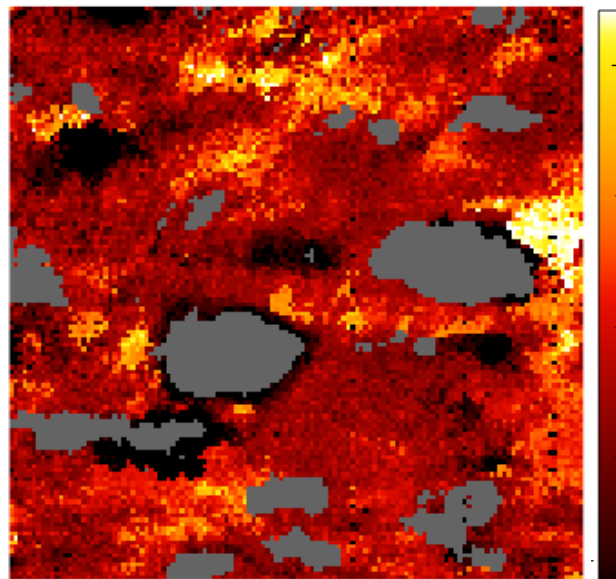
Yellow : Amorphous hydrated silicates + carbonate + sulfate = 2,47 %

Orange : silicates hydratés et désordonnés + carbonate = 4,33 %

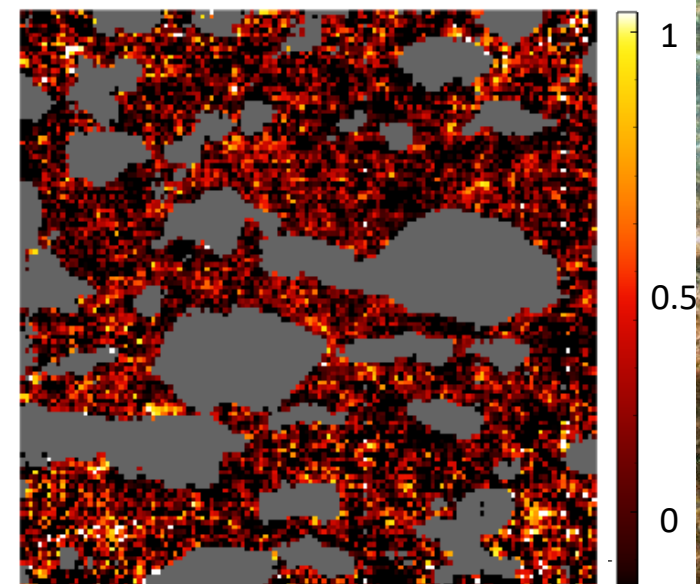
Analyse of the cluster of the matrix



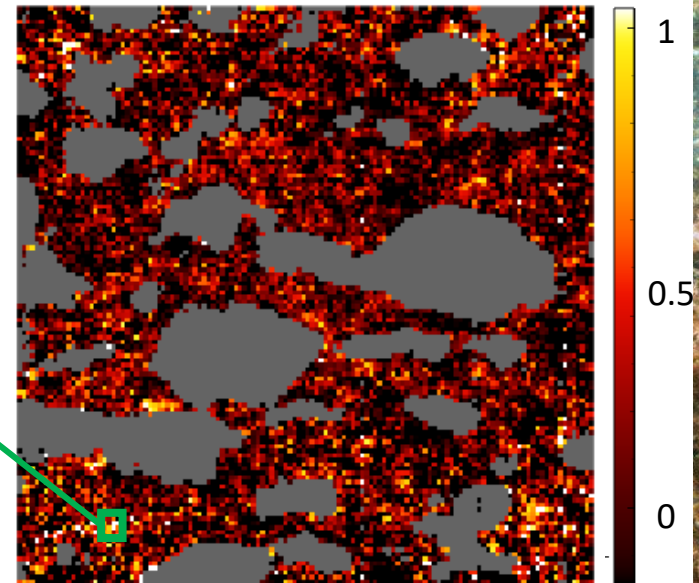
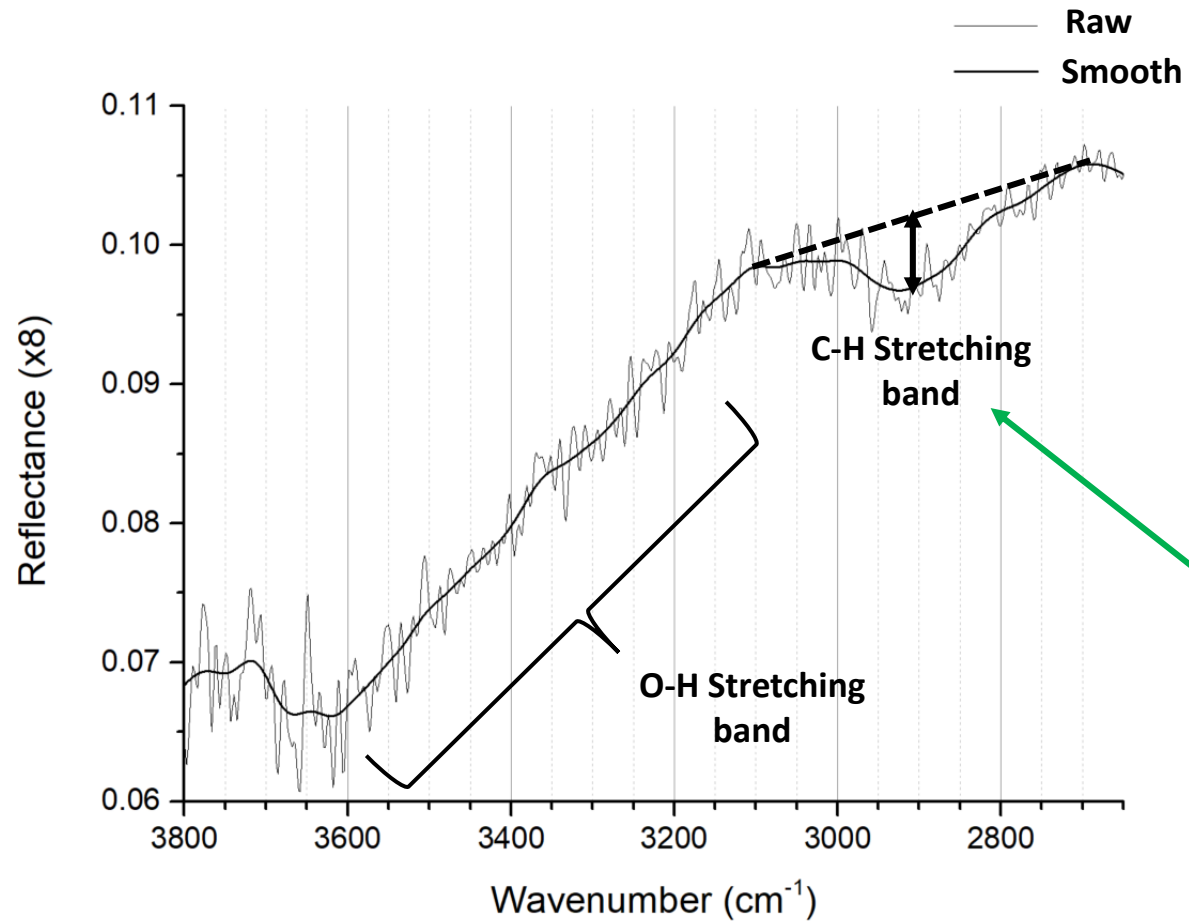
Photography with a macroscope of the analyzed surface



Mapping of the position of the maximum intensity of the stretching band of SiO in the phyllosilicates cluster

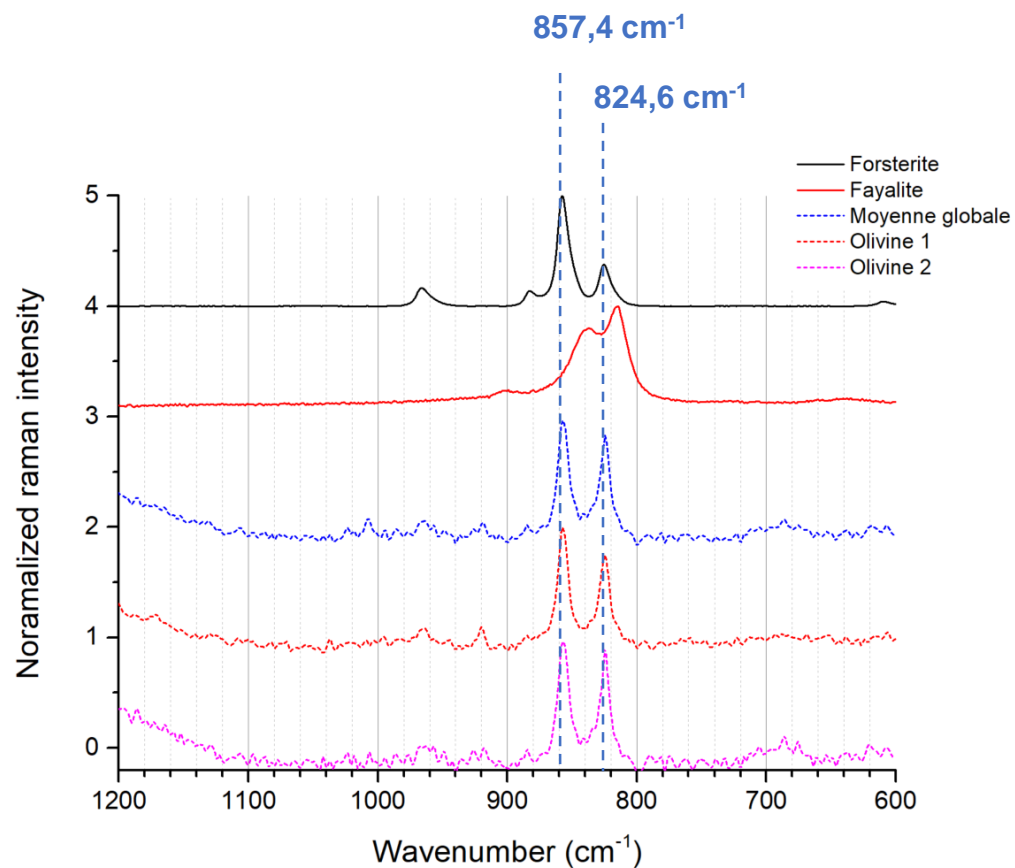


Mapping of the area of the stretching band of Ch liaison in the phyllosilicate cluster

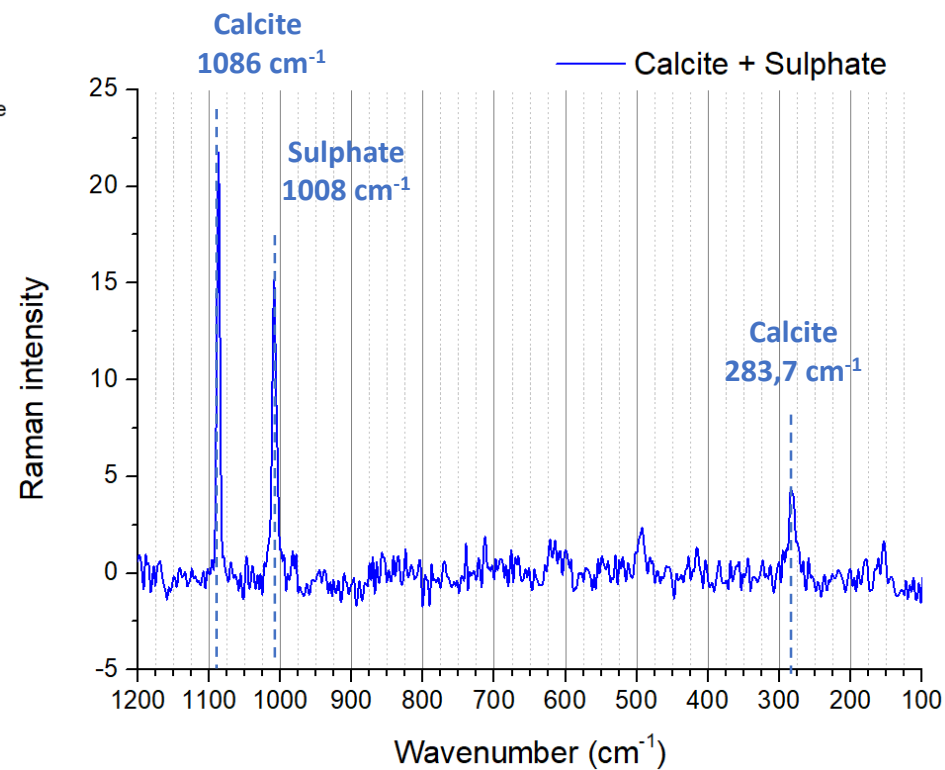


Mapping of the area of the stretching band of *Ch liaison* in the phyllosilicate cluster

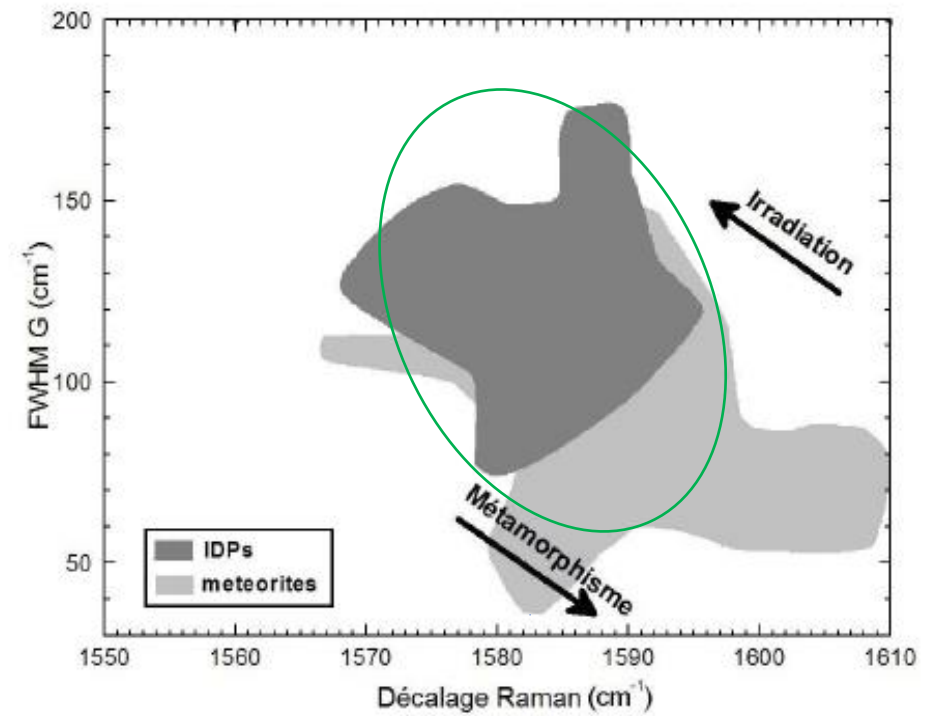
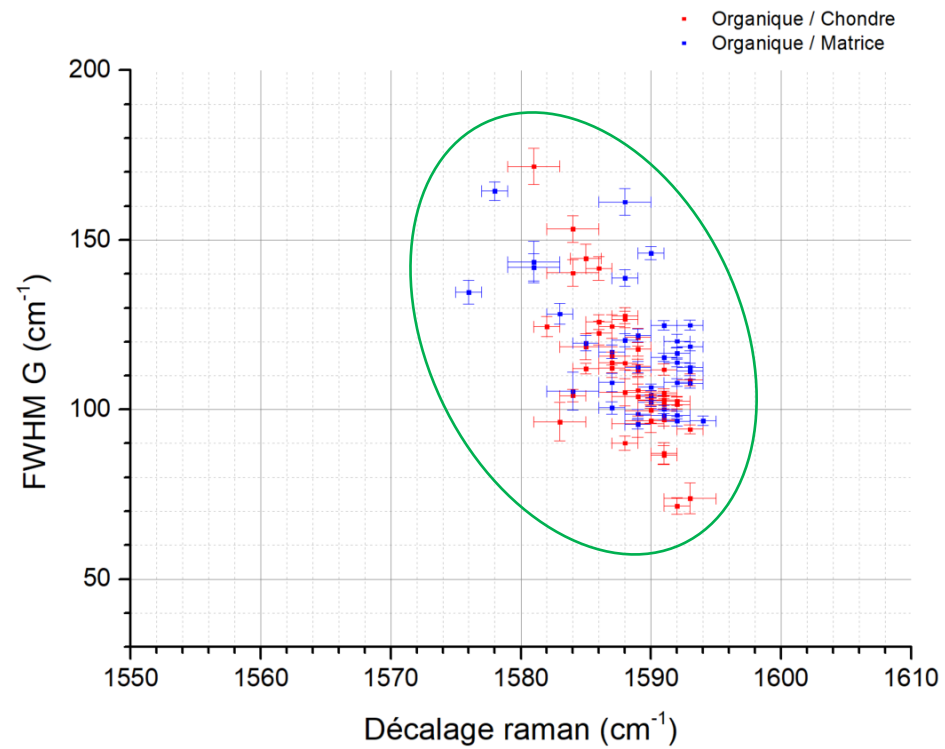
Raman spectroscopy



% Forsterite (Mg_2SiO_4) : $97,8 \pm 10$ (100-87,8%)



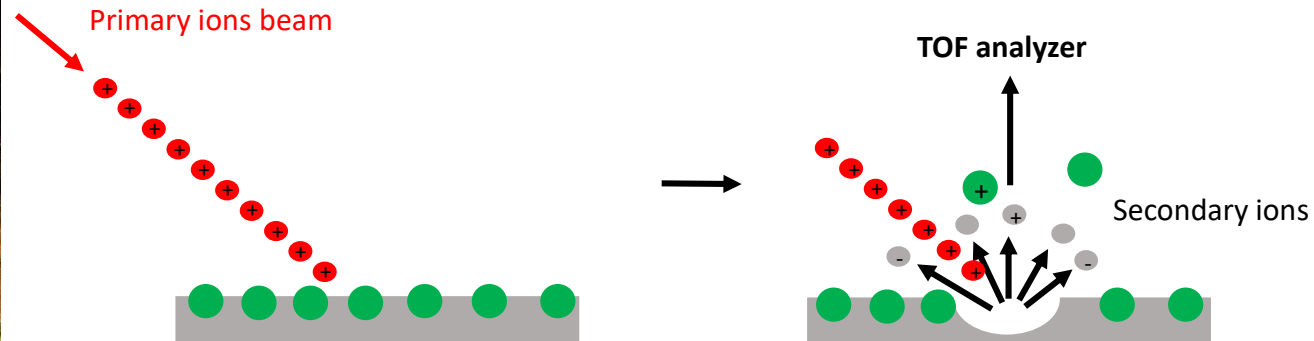
Calcite : CaCO_3



Rotundi et al, 2008

TOF-SIMS mass spectrometry

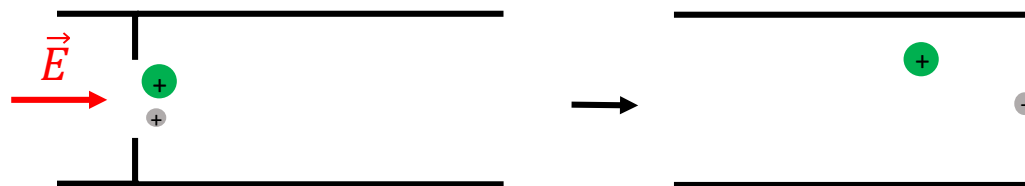
Secondary Ion Mass Spectrometry (SIMS)



ION-TOF (Liban)

Primary beam: Bi_3^+
Energy: 25 keV

Time Of Flight (TOF)

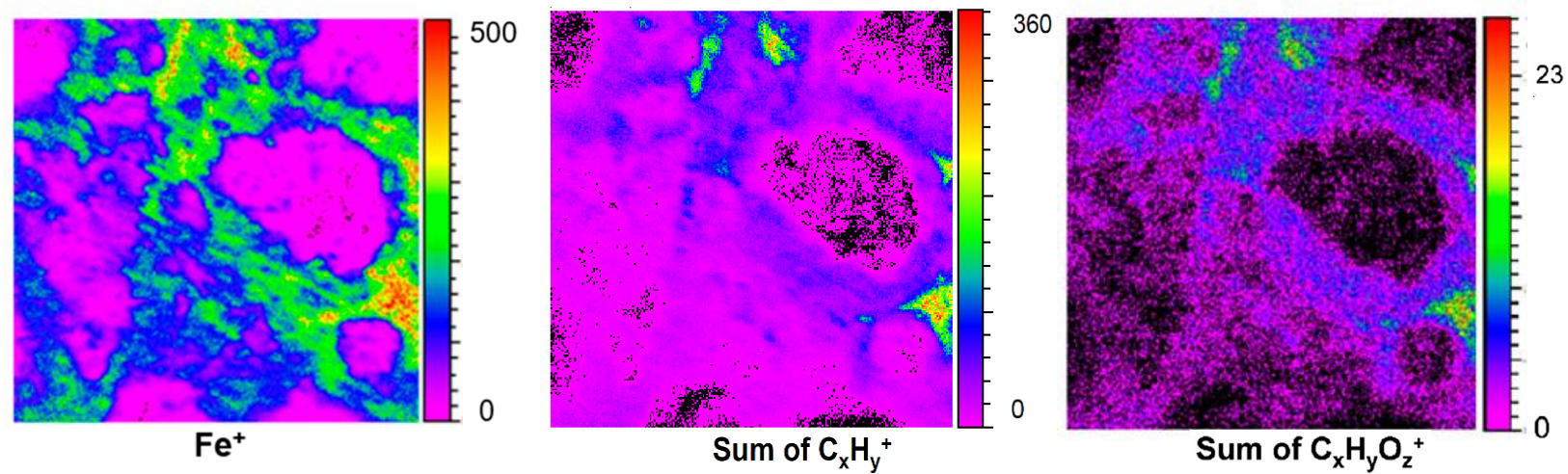


Goal :

- Characterization of the chemical structure of the organic matter
- Comparison of the spectral print of chondrites
- Spatial localisation

Paris (CM2,8)

Noun M., Baklouti D. et al., Life, 2019



TOF-SIMS mapping (commercial spectrometer, Bi_3^+ , 25 keV) of Paris meteorite

Thank you for your attention

