Analyze of meteorites and analogs by TOF-SIMS on Andromede

18/01/2022

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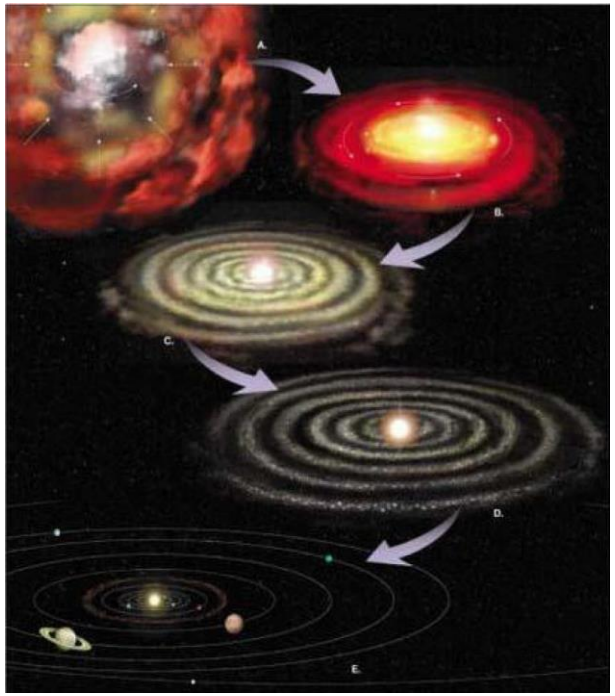
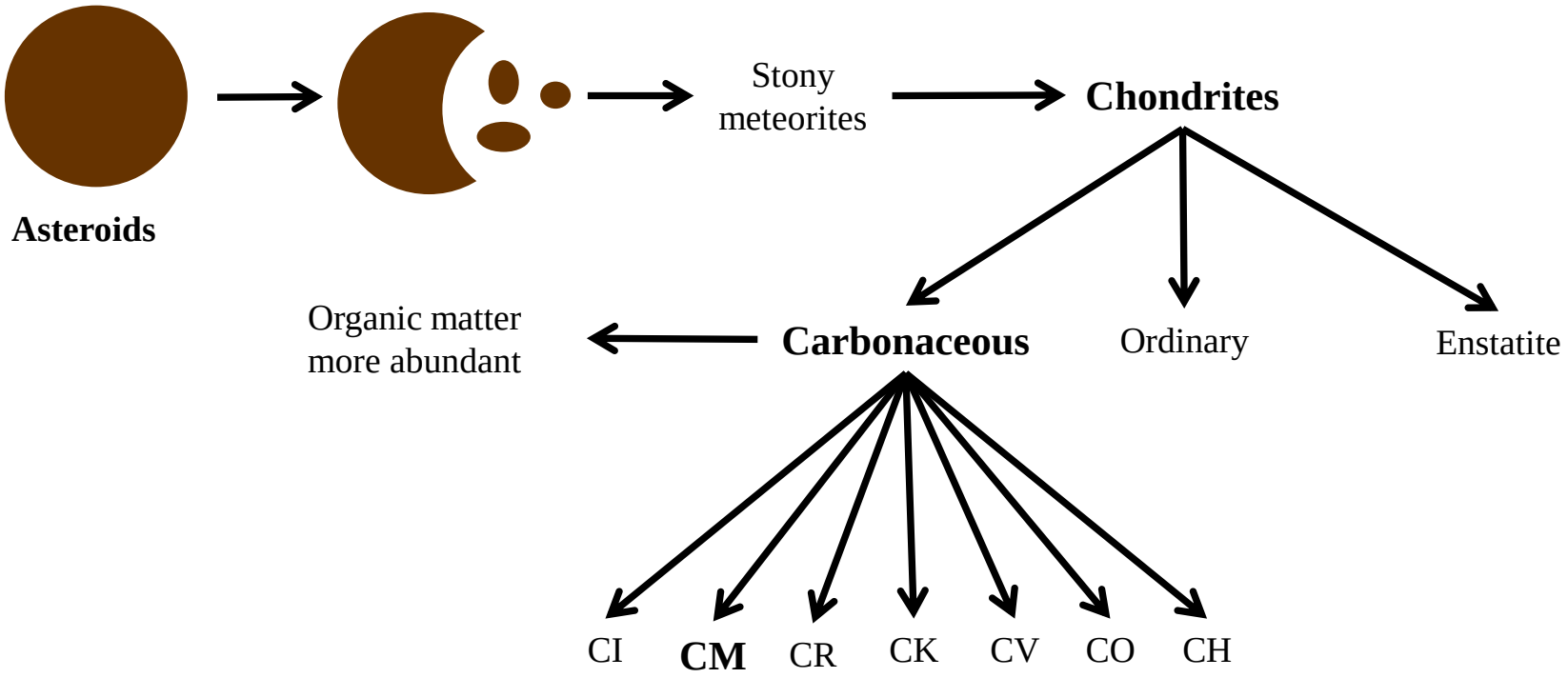
- **Astophysical context**

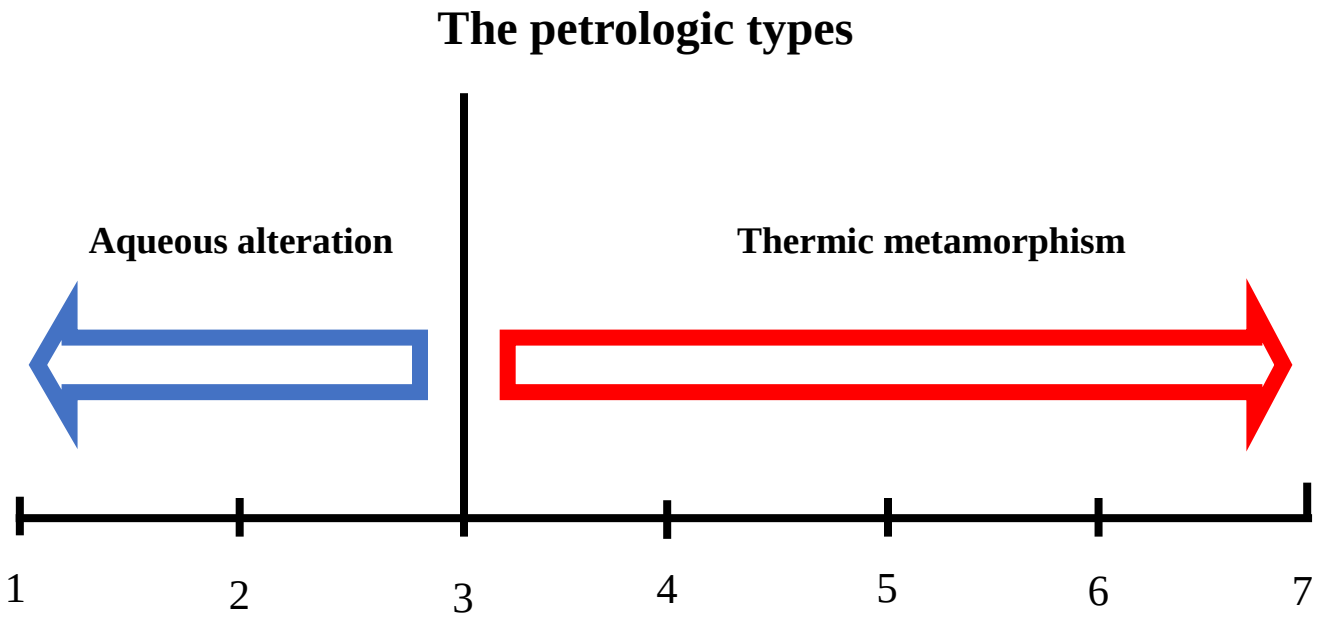


Non differentiated parent bodies:

Low chemical evolution

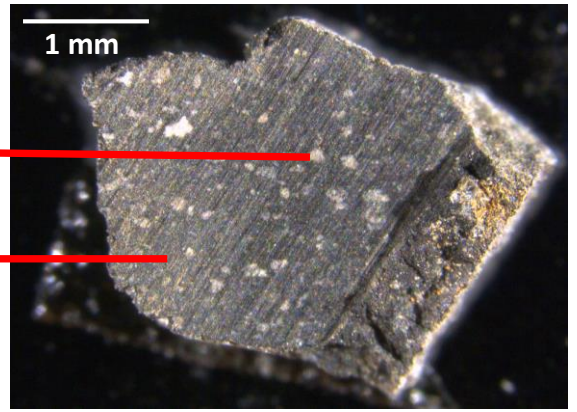


- **Astophysical context**



Chondrules and CAIs : light, anhydrous silicate M_xSiO_y
avec M = Fe, Mg, Al, Ca …

Matrix : dark, phyllosilicate $M_xSiO_y(OH)_z$
avec M = Fe, Mg, Al, Ca …



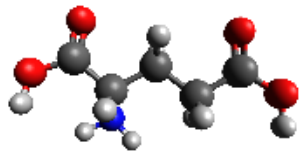
Cold Bokkeveld
CM2.2

- **Astophysical context**

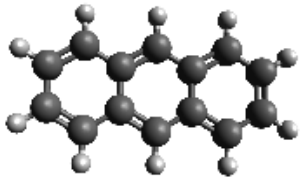
Organic matter in chondrites

Soluble Organic Matter (SOM)

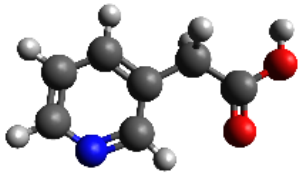
≈ 30%



Acides aminés



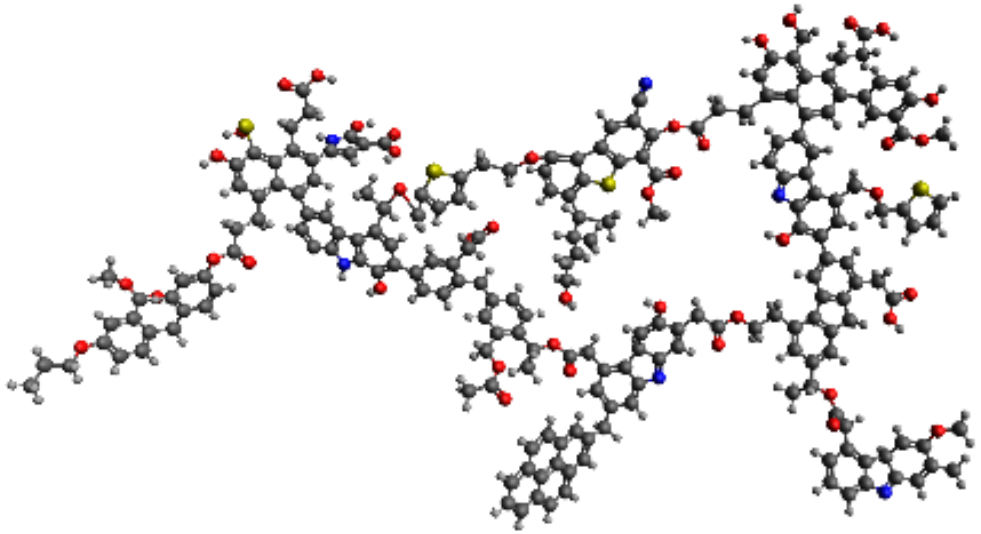
Hydrocarbures



Acides pyridiniques

Insoluble Organic Matter (IOM)

≈ 70 %



Two families with distorted proportions due to extraction and hydrolysis
Characterize the primitive extraterrestrial organic matter ***in situ*** in the chondrites with different degree of hydration :
⇒ Understand the physico-chemical interactions between the organic and mineral phases.
⇒ Reconstruct the chemistry at the origin of the formation et the evolution of this organic matter.

- **Methods**

Spectroscopies (Reflectance I.R. et Raman) paired with the imaging

complementarity

TOF-SIMS (ION-TOF) paired with the imaging

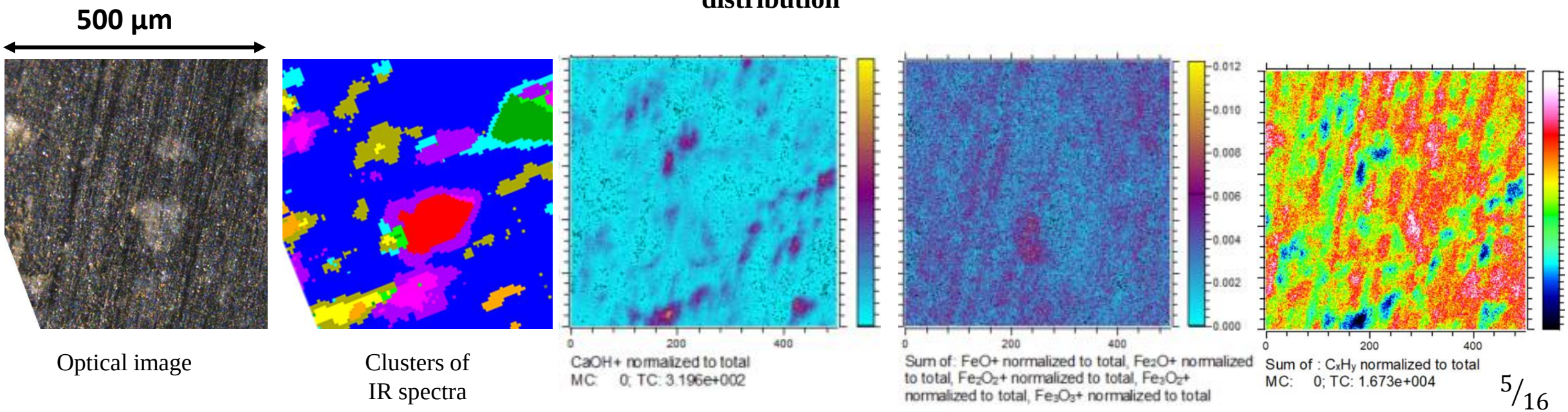
- Identification of chemical functions
- Characterization of hydration
- Characterization of the mineralogy

Spatial resolution = 5,5 µm

- Chemical and structural characterization of organic and mineral
- Detection of organometallic molecules

Spatial resolution = 2 µm

Study of the spatial distribution



- **Methods**

Use of Andromede with Au_{400}^{4+} primary ions (spatial resolution : 200 µm)

$\Rightarrow$ Better ionization yields of high mass (m/z > 1000)

$\Rightarrow$ Detection of fragments of macromolecular organic matter

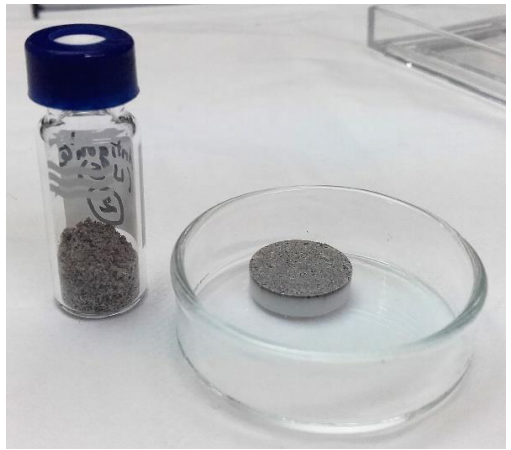
Analyze of analogs for the understanding of the measurements and the optimization of the experimental setup

- **Analogs**

Mineral analogs

Natural silicate pellet :

- Phyllosilicates
- Anhydrous silicates



Pastille d'antigorite

Organic analogs

Films deposited on a substrate:

- Polypeptide
- Macromolecular analogs produced in laboratory

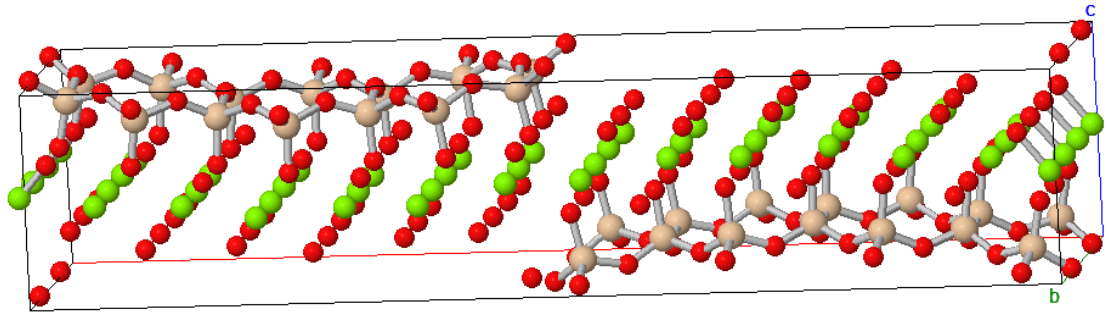
Film producted from a plasma of MeOH

Silicates and organic matter mixed

- **Analogs measurements**
  - Antigorite ($Mg_3Si_2O_5(OH)_4$) and Forsterite (Mg_2SiO_4) : positive mode

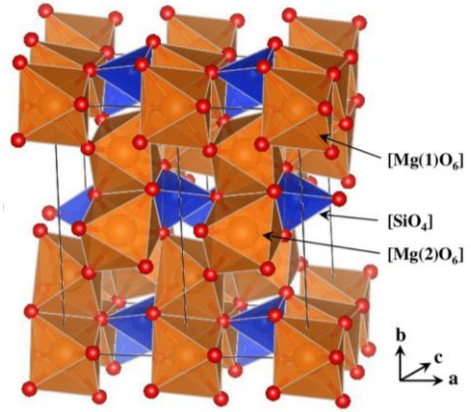
Antigorite

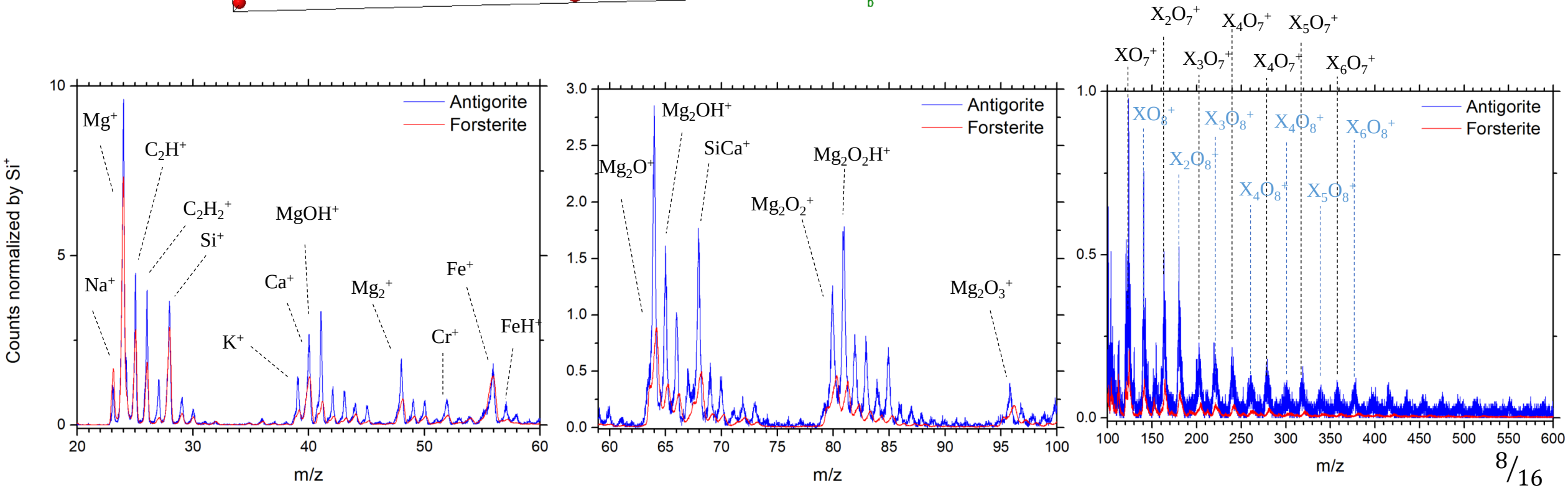
Measured on february 2019



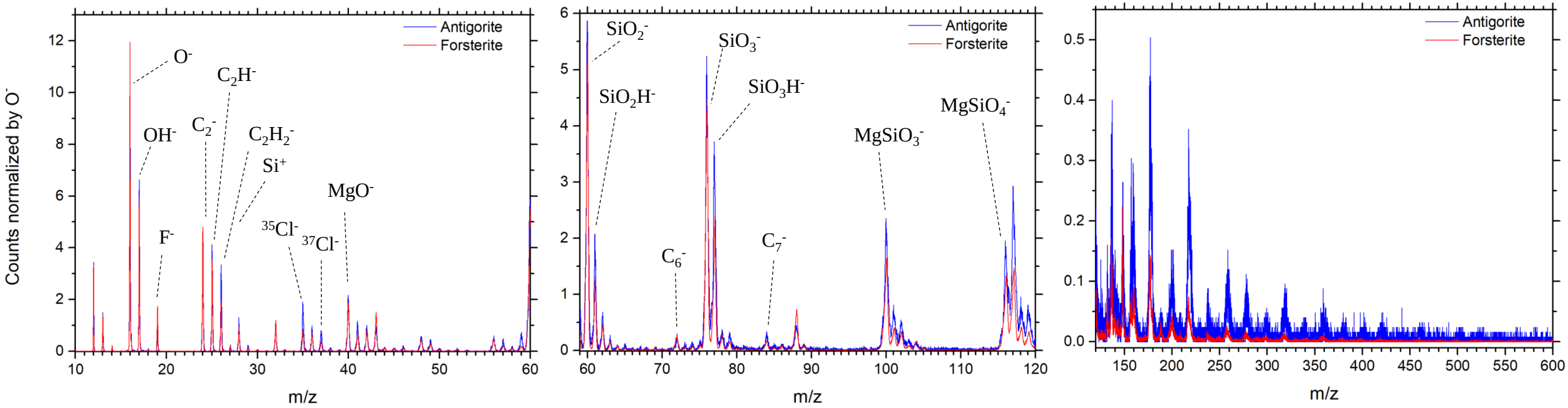
Forsterite

Measured on october 2021





- **Analogs measurements**
  - Antigorite ($Mg_3Si_2O_5(OH)_4$) and Forsterite (Mg_2SiO_4) : negative mode

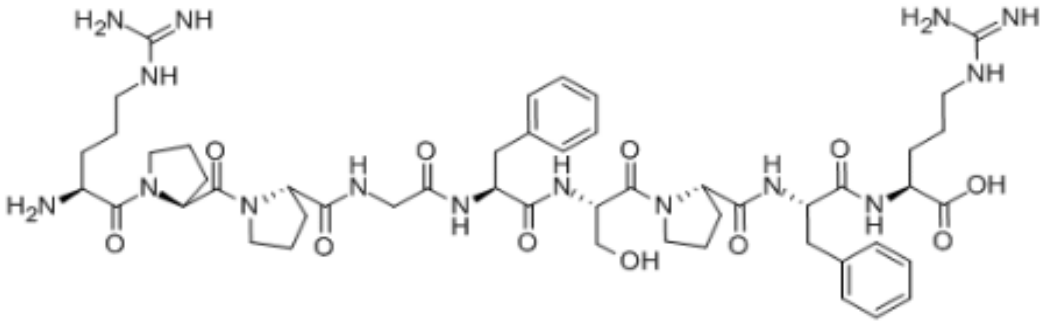


- Same mineral peaks between Antigorite and Forsterite
- Difference of relative intensities =>
  - some trace elements with different proportions (Na, Cr, K, Ca, F, Cl)
  - different pattern for the high mass oxide (K, Si, Ca or Mg)
- Numerous organic peaks
- Low mass resolution

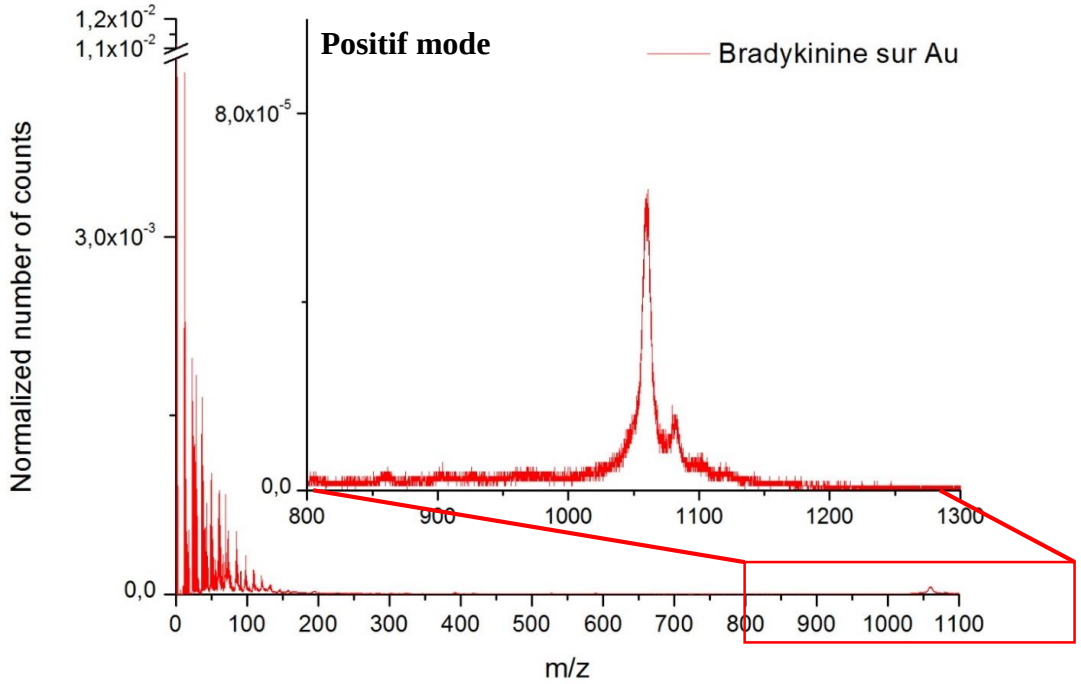
- **Analogs measurements**

Measured on march 2019

  - Bradykinine on gold surface



Bradykinine = polypeptide

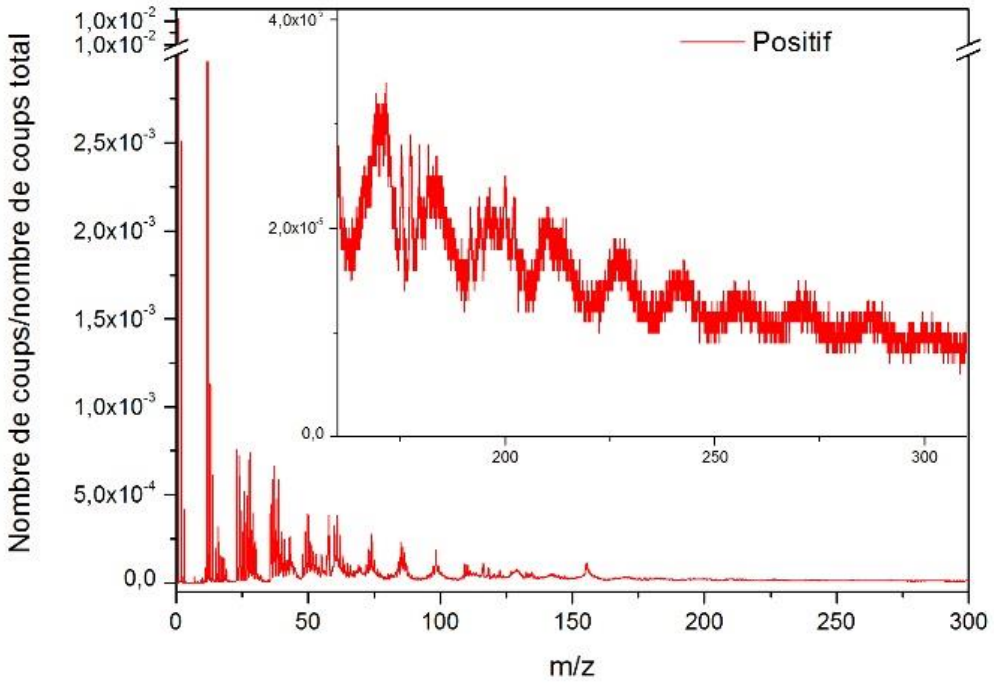


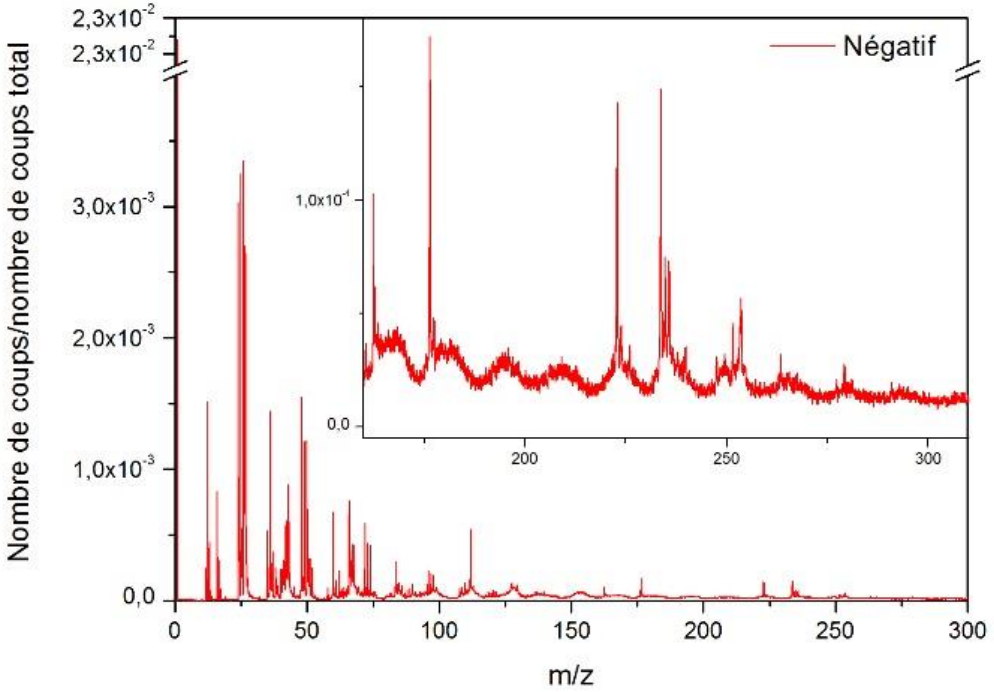
  - Presence of low mass organic peaks = fragments
  - Presence of the molecular peak of bradykinine (m/z = 1060) and bradykinine + Na (m/z = 1083)

- **Analogs measurements**

Measured on march 2019

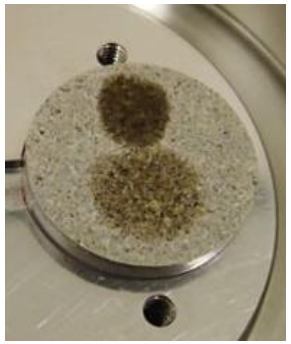
- Film CHON (Carbon + hydrogen + oxygen + nitrogen) on MgF_2 window :



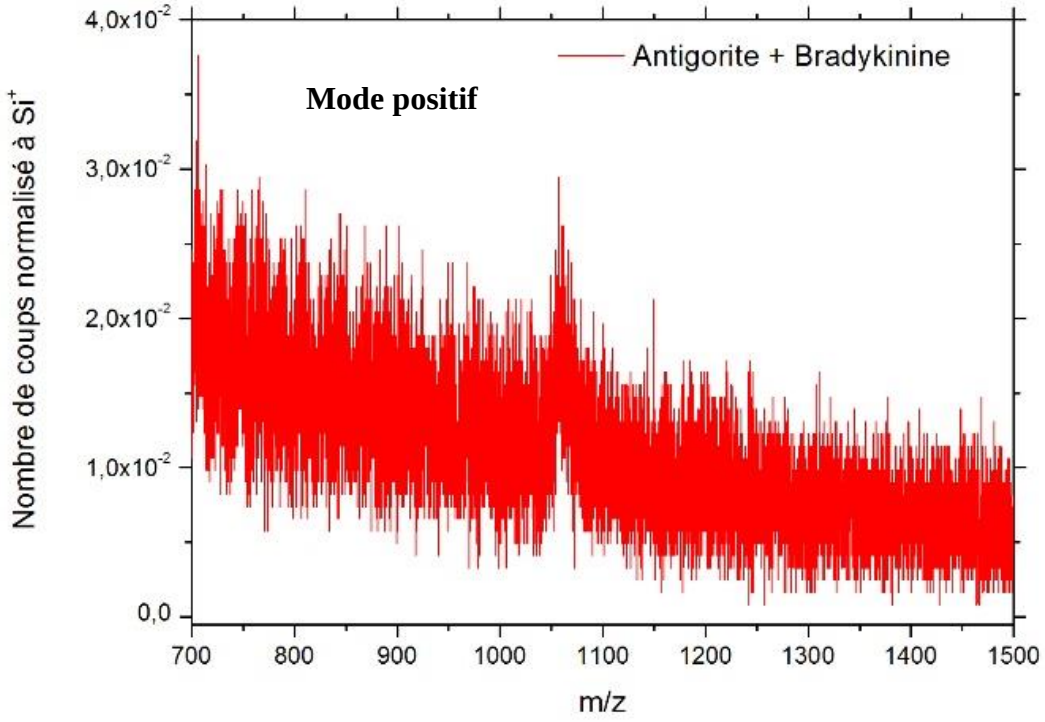


- Presence of low mass organic peaks = fragments.
- Statistical distributions of peaks characteristic of a polymeric : intensity exploitable to m/z = 330-370)

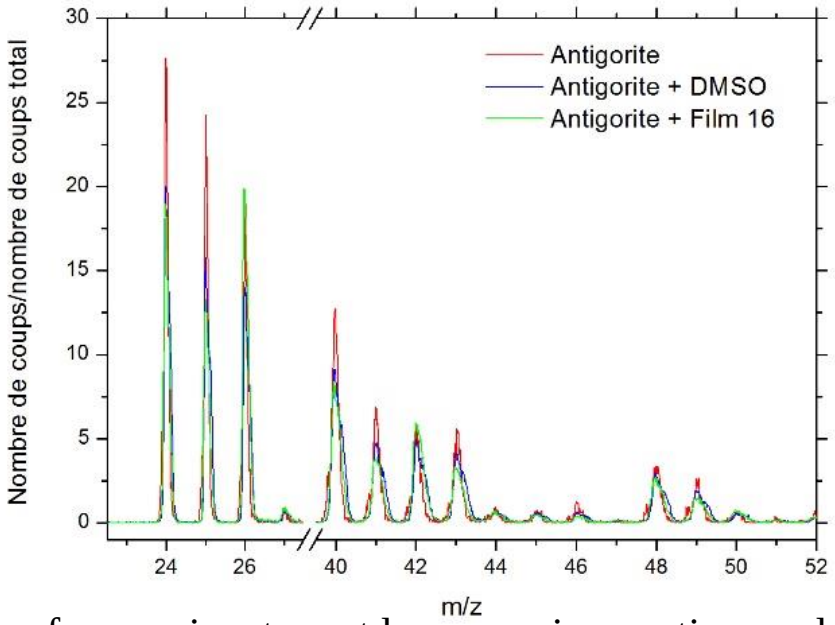
- **Analogs measurements**
  - Antigorite with bradykinine or film CHON



Measured on april 2019

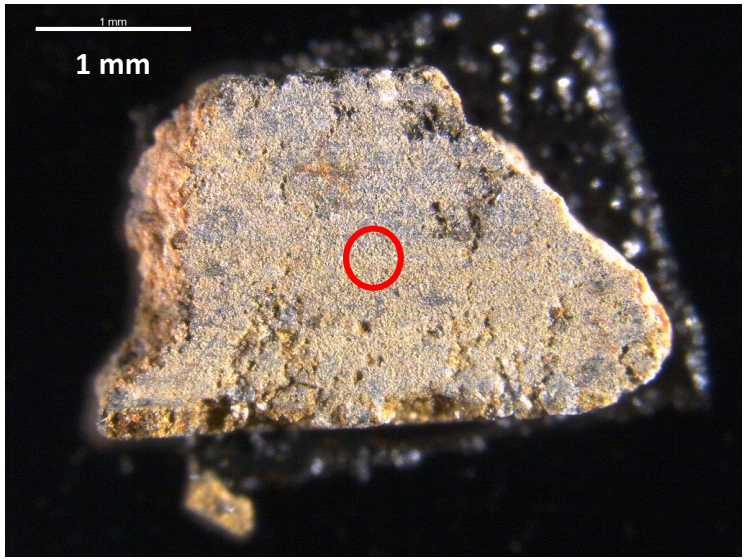


- Increase of some signatures at low mass
- Molecular peak of bradykinine
- Signal/noise ratio lower :
  - ➢ infiltration of the bradykinine = dilution effect
  - ➢ ionization of the mineral of the pellet more efficient

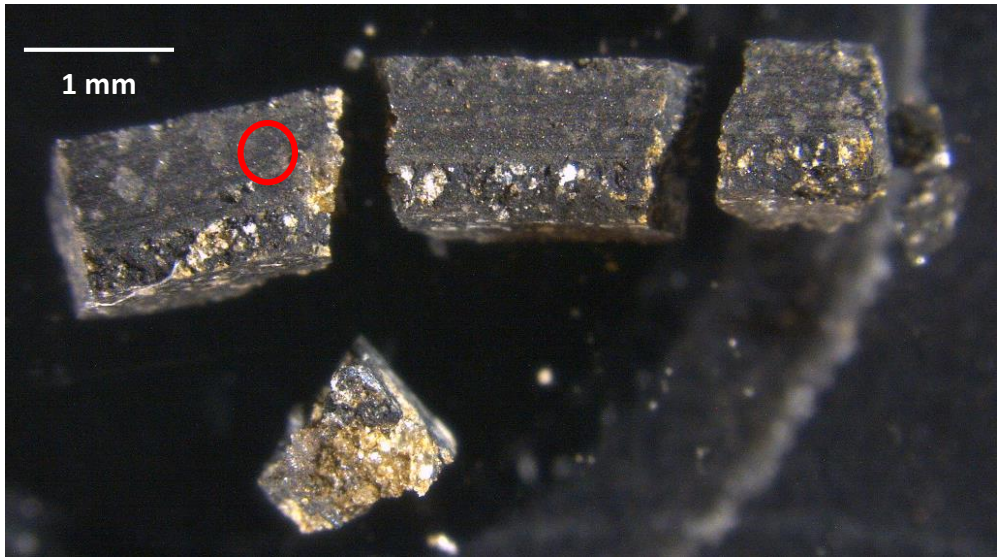


- Increase of some signature at low mass in negative mode
- No signature of the polymeric structure of the film
  - ➢ infiltration of the bradykinine = dilution effect
  - ➢ ionization of the mineral of the pellet more efficient
- enlargement of all the peaks:
  - ➢ « matrix » effect film/antigorite
  - ➢ Topological effect: surface modification due to the deposit

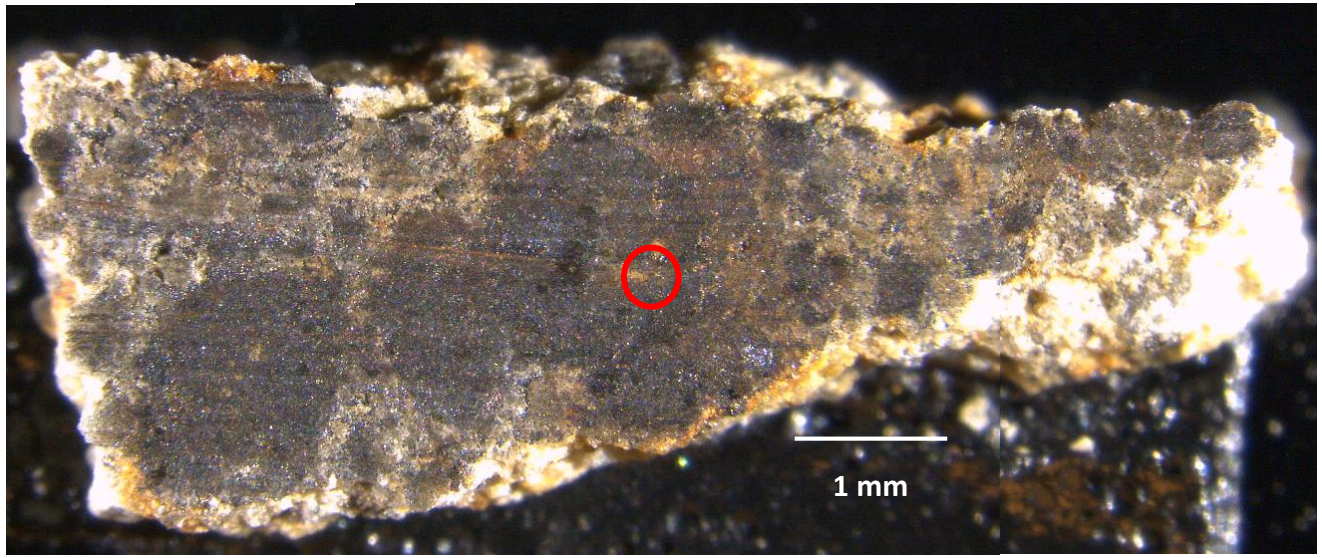
- **Chondrites**



NWA 5515
CK4



Paris
CM2,7-2,9

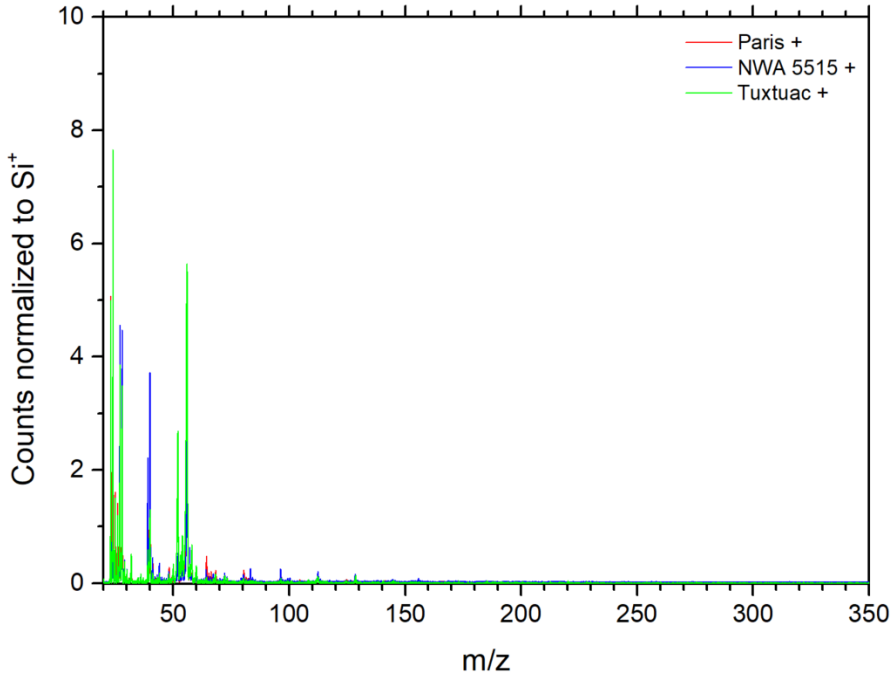


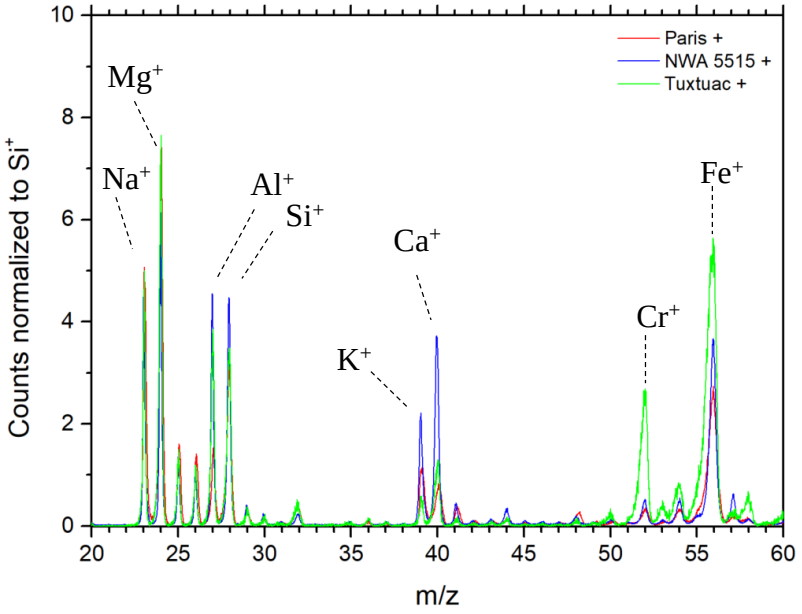
Tuxtuac
LL5

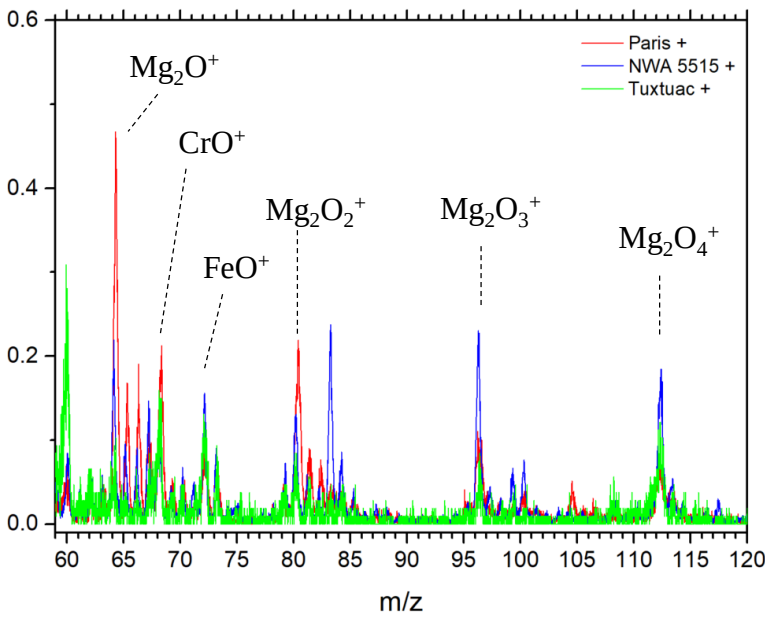
- **Chondrites measurements *(preliminary results)***
  - Positive mode

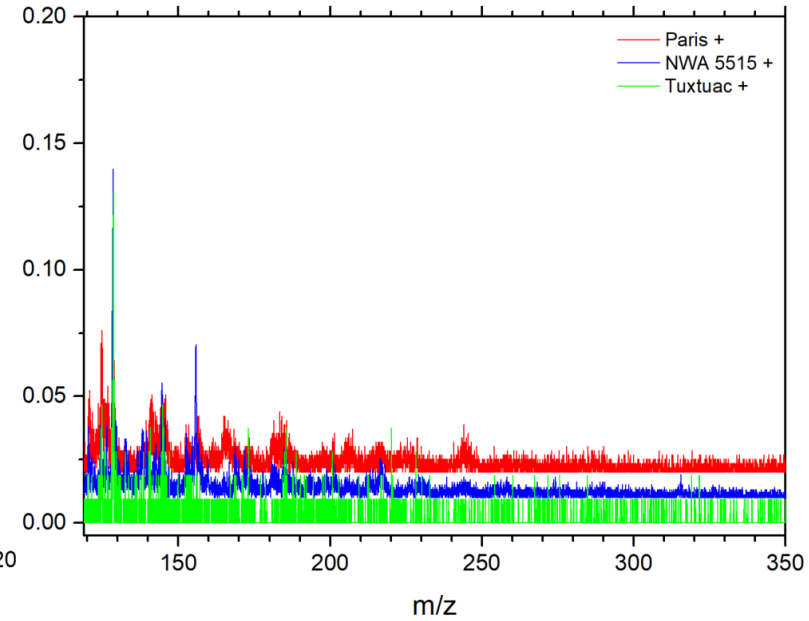
Measured on october 2021

- Low mass : mineral elements
- High mass : structural pattern of minerals (oxides et hydroxides)
- Low intensities: rim effects decreasing the detection of secondary ions





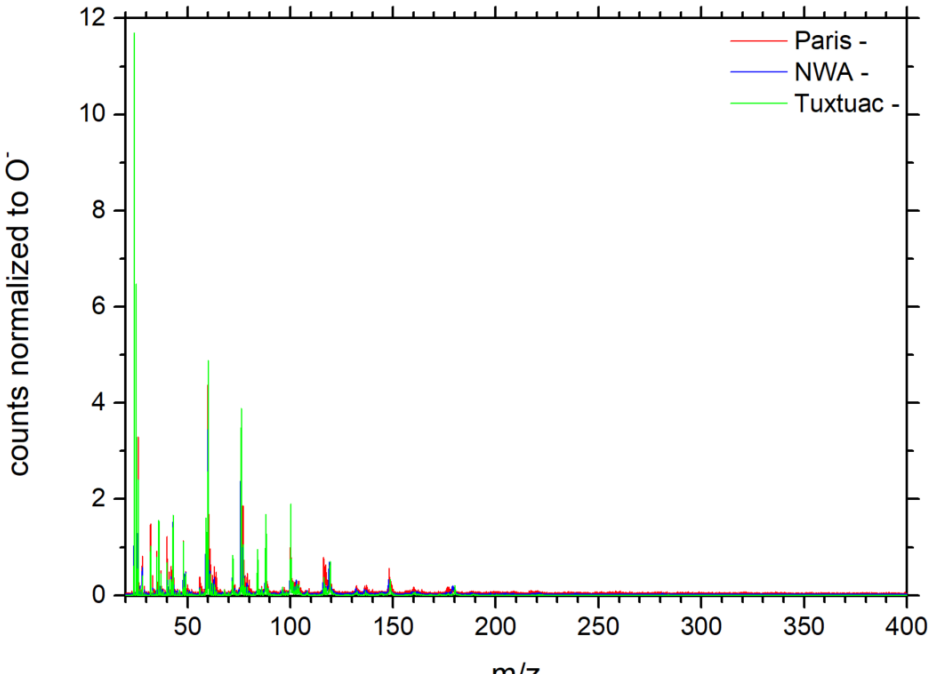


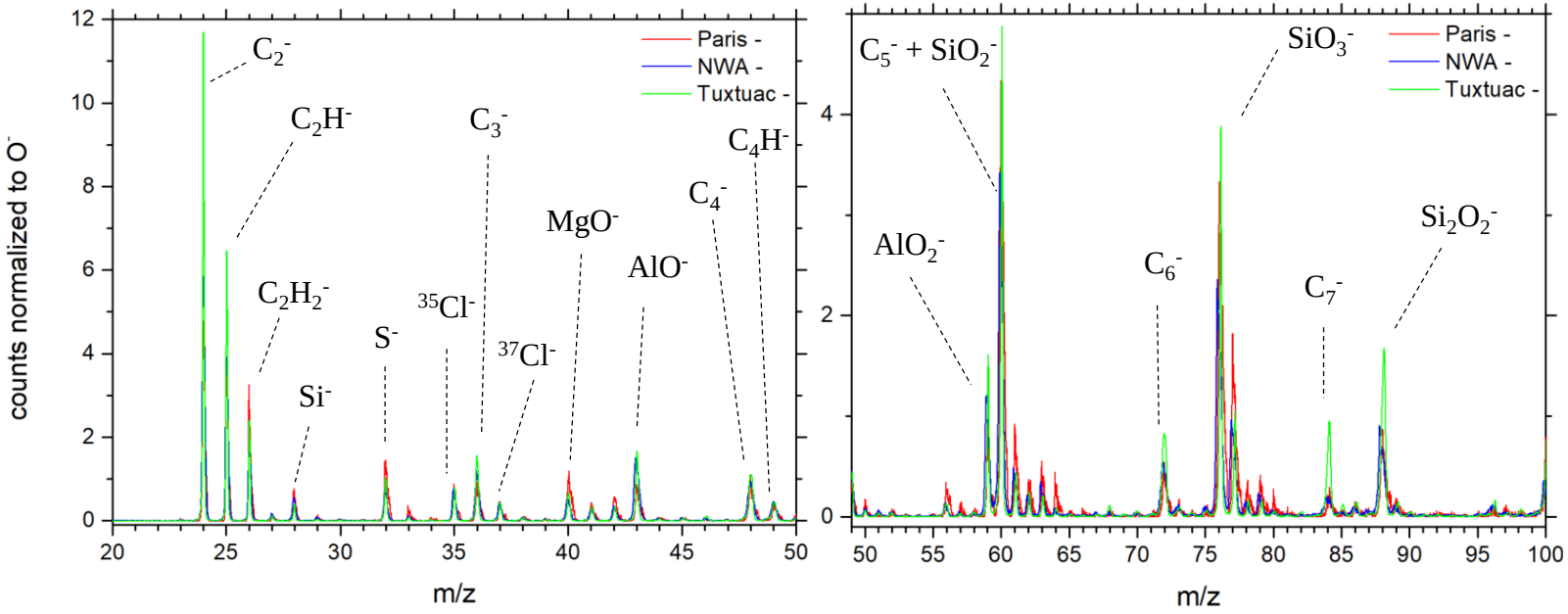


- **Chondrites measurements *(preliminary results)***
  - Négative mode

Measured on october 2021

- Low mass: organic fragments, oxide of some minerals and salts anion (Cl^-, F^-…)
- High mass : structural pattern of minerals (oxides and hydroxides), but no high mass of organic matter





- **Plan for the future**

Supplementary measurements needed :

- Chondrites measured on ION-TOF (Cold Bokkeveld and Paris) => comparison ION-TOF/Andromede
- Chondrites with 3D mold around the samples =>increase of the secondary ions collected
- News organic samples => Characterize them and increase the database of Andromede

Adaptation of the experimental setup:

- Addition of a reflector : increase of the mass resolution
- Addition of the imaging (camera + automatization)
- Addition of an electron canon : decrease of rim effect