

**NANOSIMS IMAGES OF PRECAMBRIAN FOSSIL CELLS** F. Robert<sup>1</sup>, M. Selo<sup>1</sup>, F. Hillion<sup>2</sup>, A. Skrzypczak<sup>3</sup> <sup>1</sup>LEME, CNRS-Muséum, 75005 Paris, France ([robert@mnhn.fr](mailto:robert@mnhn.fr); [selo@mnhn.fr](mailto:selo@mnhn.fr)), <sup>2</sup>Cameca Courbevoie, France ([hillion@cameca.fr](mailto:hillion@cameca.fr)) <sup>3</sup>ENSCP, 75231, Paris Cedex France.

## Introduction

Judging from the occurrence of micro-fossils in sedimentary rocks, life was dominated by prokaryotic microbes during the early Precambrian [1]. Fossils of such microorganisms are rare, incompletely preserved in geological materials and show morphologies that can be mimicked by a variety of non biological structures such as inorganic minerals, ore deposits or simple local chemical heterogeneities of the host matrix. Discriminating between true microbial fossils and “pseudo-fossils” is thus, a central issue for the study of the appearance and evolution of life on Earth.

The simple morphology is not considered as a valid criterion for the identification of a microfossil and several additional conditions has been defined to confidently ascribe a visual structure to remains of life. Considered alone, none of these conditions is a definitive proof and several of them are required in the same sample to establish the presence of life in sedimentary rocks before their compactions and solidifications.

By combining a visual image – through the optical microscope – with a chemical image, it should be possible to better address this issue. Similar attempts have been performed by Schopf et al., [1] through micro-Raman spectroscopy. With this technique, it is possible to show that organic carbon is present as a kerogen-like structure constituting the skeleton of the visual image. However Brasier et al., [2] have pointed out that such an association between organic carbon and a visual morphology should not be taken as a face value for the presence of a true fossil. Conversely, these authors suggested that an abiotic organic synthesis (Fischer-Tropsch type) could be at the origin of this “kerogen”, formed abiotically in hydrothermal conditions.

With a detailed chemical image, it should be possible to go a step further in this debate by surveying several of the chemical elements which actually enter in the constitution of bacteria or cells : H, C, N, S and eventually P, Mg, V... It should be possible to address an important point in this debate: does this “kerogen” is made of hydrocarbons (as implied by the Fischer-Tropsch synthesis) or does it contain hetero-elements reflecting the chemical fractionation patterns usually realized by living organisms ? In this respect, nitrogen is probably the best marker since its association with carbon is essentially realized through biotic fixation processes.

Previous attempts to obtain a carbon image - along with measuring the carbon isotope composition of Precambrian fossils has been made by using ion

microprobe analysis (with the ims 1270). However the maximum spatial resolution (i.e.  $\approx 1\mu\text{m}$ ) which could be attained with this instrument is of the same order of magnitude than the size of fossils cells and larger than that of bacteria. Therefore, the resolution of the optical image remains higher than the chemical's and the direct comparison between the two images is impossible.

Using the newly acquired NanoSims 50 of the Paris Museum, this issue is overcome since the spatial resolution can reach – with a Cs beam –  $0.05\mu\text{m}$ . As a first test of this approach, we have analyzed the C,N,S distribution in one of the most classical occurrence of micro-fossils of the Precambrian period : the cherts from the Gunflint formation at Schreiber Creek (samples provided by S. Awramik). Since there is a scientific consensus that this geological formation contains one of the oldest and remarkably preserved Precambrian flora, the chemical nature of the kerogen constituting these fossils has been analyzed for C, N and S.

## Results

The results reported in Figures 1 and 3 ( $8\times 8\mu\text{m}$ ) were selected among several detections where such images correspond to filaments or individual cells. All the images correspond to the same cell. The chemical images (Figures 1) were recorded with a measured spatial resolution of  $0.07\mu\text{m}$ . According to the published taxonomy of Precambrian fossils [3] the optical morphology reported in Figure 2 can be attributed *Mainauacula epixebon*. Judging from its lower C/N ratio (Figure 3), the “membrane” of the cell is less mature than the nucleus which is more graphitic. Nevertheless the combined occurrences of C-N can be regarded as a solid evidence according to which the organic matter constituting the living cell, was not remobilized by sedimentary fluids. Of course, the molecular constituents have been profoundly transformed by diagenesis and/or by the post depositional geological history of the sample, as attested by their high C/N ratio.

## Conclusions

Judging from this study, it is now possible to look for much older Precambrian samples, the origin of which is highly debated, namely Cherts of the Warrawoona Group in Western Australia. With this new technique, it could be eventually possible to better constrain the age of life on Earth. An attempt to find these chemical markers in cherts will be shown at the meeting.

**References:** [1] Schopf W.J., Kudryavtsev A., Agresti D., Wodwiak T. and Czaja A (2002) *Nature* **416**, 73-76. [2] Brasier M.D., Green O.R., Jephcoat A.P., Kleppe A.K., Kranendonk M.J.V., Lindsay J.F., Steele A. and Grassineau N.V. 2002) *Nature* **416**, 76-81. [3] House C.H. et al., (2000) *Geology* **28**, 707-710.

Figures 1a, 1b, 1c. : NanoSims image of C, CN and S in the Gunflint chert (scale 8x8  $\mu\text{m}$ , resolution 70 nm; color concentrations in Log Scale)

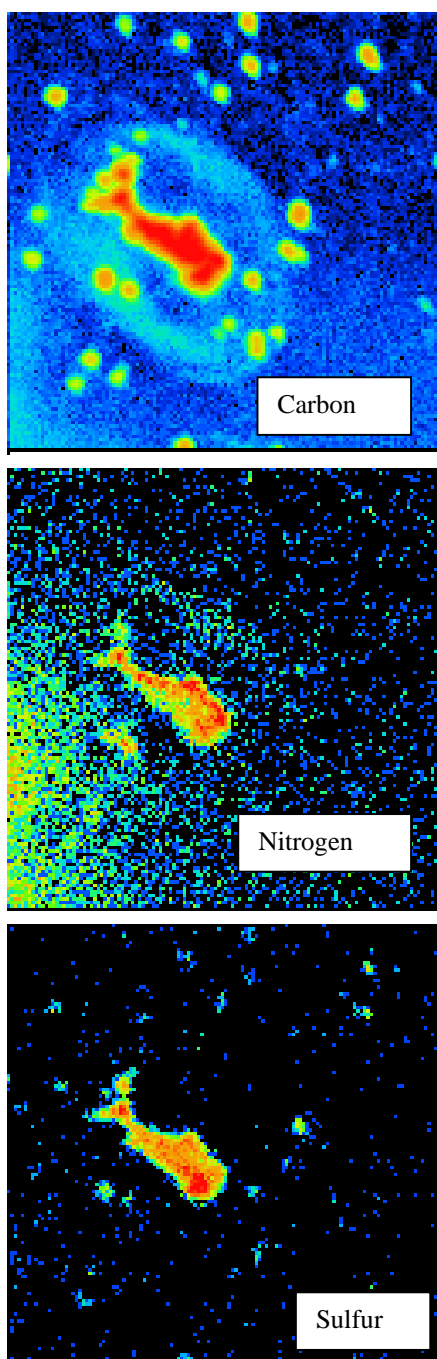


Figure 2 : Optical image of Figures 1



Figure 3 : C/N ratio of Figure 1a and 1b. (C/CN ratio in Log scale)

