DETECTION OF BIOSIGNATURES IN SILICIFIED ROCKS USING RAMAN SPECTROSCOPIC MAPPING.
F. Foucher[1], M.-R. Ammar[2] and F. Westall[2], [1]CBM, UPR CNRS 4301, Rue Charles Sadron, CS80054, 45071 Orléans Cedex 2, France, frederic.foucher@cnrs-orleans.fr, [2]CEMHTI, UPR CNRS 3079, Univ. Orléans, 45071 Orléans Cedex 2, France.

Introduction: Potential microfossils dating back to the Noachian on Mars (-4.5 to -3.5 Ga) may have been silicified by hydrothermal fluids and could thus be very similar to the oldest traces of life found on Earth in cherts from Australia and South Africa (3.5 Ga old) [1-4]. Due to the small size and simple shapes of these microbial remains, their biotic origin and syngenecity is often difficult to demonstrate and requires sophisticated instrumentation [3, 4]. The detection and resolution limitations of space qualified instruments will make this demonstration all the more complicated on Mars during future *in situ* missions [5]. In this context and in view of the fact that Raman spectrometers will be part of the future ExoMars 2018 and Mars 2020 mission payloads, we have made a study of the potential of Raman spectroscopy to detect possible biosignatures that could be observed on Mars. In particular, we used the mapping mode to highlight variations in the mineral matrix and carbonaceous matter signals associated with silicified microorganisms.

Materials and methods: The Raman spectrometer used was a WITec Alpha500 RA equipped with a green Nd:YAD frequency doubled laser at 532 nm wavelength. We focussed our study on silicified microorganisms from the Draken formation, Svalbard, 800 Ma. All the analyses were made on 30 µm thick polished thin sections (Fig. 1).

Results:

Opaline silica. We were able to detect and identify micrometric mineral phases associated with the biological remains, some of them potentially of interest as biosignatures, such as hydroxyapatite. More interestingly, we were able to detect opaline silica directly associated with carbonaceous matter [6]. If this metastable mineral normally converts to quartz, we show that this conversion has been inhibited by the carbonaceous matter within which the opal precipitated (Fig. 1b). We were also able to demonstrate that this association could be considered as a good biosignature.

Heterogeneity in Raman signal of carbonaceous matter. Interestingly, the Raman maps also document very fine variations in the spectrum of the carbonaceous matter. In particular, the distribution of the intensity ratios of the two main carbon peaks of the spectrum are directly associated with the microfossil shape as seen in Fig. 1c. We interpret this non-random distribution as a consequence of compositional variations in the precursor components [7]. Using abiotic bacteriomorph structures from the Mendon formation, South Africa, 3.3 Ga, as an abiotic control, we were able to demonstrate that such varitions are intimately linked to the biotic origin of the structure.

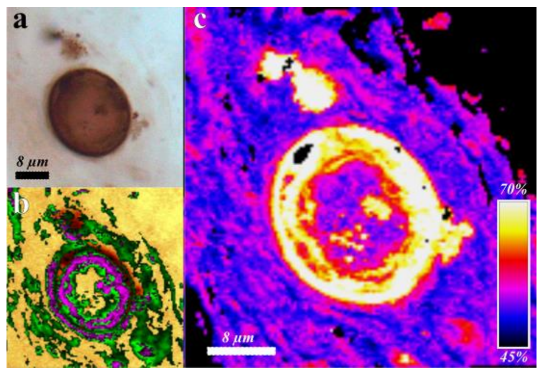

Figure 1: Raman map of silicified planktonic microorgansims from the 800 Ma old Draken formation. (a) Optical microscopic view, (b) Raman compositional map with quartz in orange, the carbonaceous matter in green and the opaline silica in purple and (c) ratio of the two main peak intensities of the carbonaceous matter spectrum.

Summary and Conclusions:

Raman mapping permits identification of certain biogenic characteristics of silicified microfossils. In particular, we documented the association of opaline silica with these structures as well as the non-random variation in the Raman spectrum of carbonaceous matter. These features could be helpful to detect potential traces of life in Martian rocks.

References:

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