Chemical identification and automatic spectral classification of Microfossils from the Gunflint chert (1,88 Ga)

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The identification of microbial remains on planetary bodies is an extremely challenging endeavor, requiring the utilization of novel measurement techniques and modern analytical approaches. We performed an extensive study of the chert sample from Gunflint formation (1.88 Ga) containing populations of Precambrian microfossils with a laser ablation ionization mass spectrometer (LIMS) (Riedo et al., 2013; Wiesendanger et al., 2018) intended for application in space. Chemical characterization on microscale can open a new perspective in the identification of microbial remains, where morphological features might be lost and provide additional lines of evidence towards proving biogenicity of a given putative sample. Chert from the Gunflint formation in this study is considered as a Martian analogue where remains of microfossils are mainly concentrated within circular and tubular structures, which are primarily made from collapsed cell walls entombed within silica.

We sampled the microfossils and surrounding chert (host area) with fs UV laser with a spot size of 8 μm and retrieved intensities of 180 consecutive single mass peaks from each mass spectrum. We collected 60'000 mass spectra and build an intensity-based classifier, intended to process large datasets from cherts and identify their classes in an automatic regime. Using elemental pair-to-pair correlation analysis, we identified relevant masses for each given mineralogical class. Additionally, we will present results of chemical imaging of the sample and discuss in details the chemical composition of microfossils and surrounding chert as well as technical aspects of the identification of spectra from the microfossils.

We will show how rich spectral information can be reduced to the low dimensional domain using principal components analysis and used for successful classification. Moreover, we will present the established workflow and discuss possibilities to extend this approach to other astrobiologically relevant formations, such as phosphates, carbonates, hydrothermal silicates. Future Mars exploration with enabling technologies as machine learning and big data processing coupled with high-output instrumentation such as laser ablation ionization time-of-flight mass spectrometry has the capacity to improve scientific return and achieve stated objectives and therefore should be given appropriate attention in the future missions.
