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Searching for extinct or present microbial life on planetary surface

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Statement of the Problem: There is a growing interest in the development of the analytical instrumentation suitable to identify past and/or present life on the other planets. A combination of laser mass spectrometry and optical microscopy can be powerful for in situ searches of extinct or extant life forms embedded in minerals. On the Earth, the microbial life forms appeared likely earlier than 3.3 billion years ago. Also, Mars is expected to be some 3.5 billion years ago habitable hosting a great body of liquid water. New planetary targets in searching for life are Europa and Enceladus with their oceans covered by ice layers. Our instrument can be used to identify locations of putative life forms on rocks or ice surface by microscopy and to deliver chemical composition by laser ablation and laser desorption mass spectrometry. The miniature instrument suit is currently being developed for the future application on landed spacecraft. Our near future activities are focused on fitting such an instrument into the stringent requirements of a space mission regarding mass, power, volume and autonomous operations.

Methodology & Theoretical Orientation: The current studies are conducted on fossilized life forms embedded in mineralogical phase. The microscope optical analysis yield morphological and spectral details of the analyzed surface. The chemical analysis (elemental, isotope and molecular) are conducted using laser mass spectrometry.

Results & Conclusions: While from the elemental analyses the identification of bio-relevant elements and an insight to possible metabolic processes can be obtained, on the other hand from the measurement of isotope ratios one can conclude on a biotic or abiotic isotope fractionation mechanism. The matrix-assisted laser desorption/ionisation mass spectrometry (MALDI) can be applied, in addition, to search for possible detection of complex organic molecules. These chemical analyses together with the morphology of the investigated feature can deliver strong evidence for the presence of simple life forms.

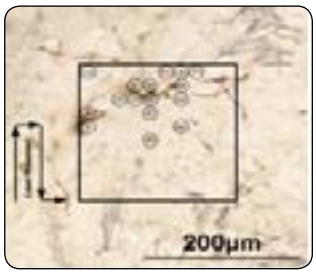

Figure 1: Fossils (black veins) of micrometer dimensions are embedded in a host matrix. The filamentous features are a micro-sized bacterial colonies

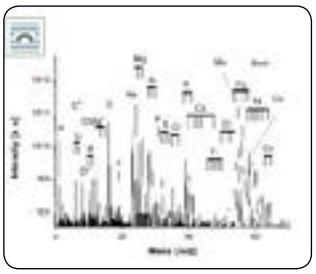

Figure 2: Mass spectra of the fossil material. Both elemental and isotope analysis delivers essential information to constrain the conclusion on abiotic or biotic origin of the sample

Recent Publications

1. A Galli et al. (2018) 0.2 to 10 keV electrons interacting with water ice: radiolysis, sputtering, and sublimation. Planetary and Space Science. 155:91-98. Doi:10.1016/j.pss.2017.11.016.
2. M Tulej et al. (2016) Experimental investigation of the radiation shielding efficiency of a MCP detector in the radiation environment near Jupiter's moon Europa. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms 383:21-37. Doi: 10.1016/j.nimb.2016.06.008.
3. P. Moreno Garcia et al. (2016) Towards matrix-free femtosecond-laser desorption mass spectrometry for in situ space research. Rapid Communications in Mass Spectrometry. 30(8):1031-1036. Doi:10.1002/rcm.7533.

4. A Neubeck et al. (2016) Mineralogical determination in situ of a highly heterogeneous material using a miniaturized laser ablation mass spectrometer with high spatial resolution. International Journal of Astrobiology. 15(2):133-146.
5. M. Tulej A et al. (2015) Chemical composition of micrometer-sized filaments in an aragonite host by a miniature laser ablation/ionization mass spectrometer. Astrobiology. 15(8):669-682. Doi: 10.1089/ast.2015.1304.

Biography

Marek Tulej has completed his PhD from Basel University, Switzerland. He is currently the Staff Member of Planetary Sciences and Space Research Division and Head of Laser Mass Spectrometry Lab in Physics Institute, University of Bern, Switzerland. He is involved in the development of a miniature analytical instruments for space missions. He is also the Science Group Member for the missions to the Moon (Luna Glob, Luna Resurs) and Jupiter satellites (JUICE). He has published more than 80 papers in reputed journals and has been serving as an Editorial Board Member, journal and proposal Reviewer. His research interest include: planetology, space research, chemical investigation of planetary surfaces and atmospheres and development of analytical instrumentation for space research.

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