In situ detection of extinct and extant microbial life on planetary surfaces

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We show that the combination of laser ablation/ionisation mass spectrometry (LIMS) and optical microscopy is a powerful combination of experimental techniques to identify microbial life on the surface of planetary bodies. Possible microbial extinct life, in form of fossils in minerals, is identified by optical microscopy in rocks on planetary surfaces. Subsequently, identified locations on rocks are investigated by laser ablation mass spectrometry to obtain the element and isotope composition of the putative fossil and of the surrounding host mineral. From the presence of elements in the sample necessary for life, elements participating in the metabolic processes, from relevant isotope ratios and from the mineralogy of the host material together with the morphology of the investigated feature one can distinguish between a fossil and abiotic matter, and get insight into the possible metabolic processes and the fossilisation mechanism.

The surface or near-surface of Mars is a high potential location for such a search for life, since large bodies of liquid water existed until about 3.5 billions years ago on its surface, and localised underground patches of liquid water might still exist. As a Martian analogous sample for fossilised life we chose Gunflint chert sample of 1.88 Ga age, for extant life we used Martian mudstone analogue samples. The Gunflint chert sample contains mainly microquartz as the primary host mineral. Microscope images show diverse morphologically preserved microfossils of different shapes, which show high C, Mg, S, Fe, Mn content with trace amounts of V, Cr, and Cu. Measurements of the host mineral contain almost negligible or noticeably lower concentrations of these elements. Also the detection of extant life in the Martian mudstone analogue samples, containing a known number density of microbes will be demonstrated. The LIMS measurements of biogenic element signatures yielded a high efficiency of microbe detection. Altogether, we will demonstrate that the LIMS instrument suite is capable of accurate and sensitive element and isotope studies with high lateral and depth resolution and able to perform an investigation of natural samples such as Si-rich cherts and collect mutually supportive pieces of evidence supporting biological origin of some of the structures inside the host matrix.