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On in situ detection of micro-sized fossils on planetary surfaces

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For most of current planetary missions, the searches and identification of present and past life forms on the planetary surfaces are one of the major scientific goal. Among others the identification of fossilised life forms in the planetary materials is important biosignature. Assuming Earth-like evolution scenario microsized cellular living or fossilised forms are likely to be found on the other planetary surfaces. Fossil evidence for cellular life in geological record is dated back close to 3.5 billion years but habitable conditions are expected to be even earlier back at least 4 billion years. So a number of Solar System bodies can likely host habitable environments including Mars, Venus, Titan, Enceladus or Europa. Evidence of microbial life can be delivered by morphological and chemical analyses of preserved cells or biologic traces in the geological rock record. Depending on the degree of preservation, elements and isotopes can be used for identification of biologic activities from abiotic signatures. A combination of optical microscopy and mass spectrometry to identify and analysed chemical composition of fossils can be powerful in such investigation. In our laboratory we use both microscope camera and time-of-flight mass analyser combined in one analytical pakage for in situ analysis. Both instruments form a prototype of space instrument package which can be applied also for investigations of planetary surfaces. The current studies are conducted with a number of fossil and putative fossil samples of different ages. The analyses form bases to establish the measurement protocol for the optimal characterisation of fossilised material. We will present results of the measurements of fossils with ages from 3.5 billion to 100 million years. The elemental and isotope composition of the objects accompanies the optical analysis with discussion of possible fractionation effects due to life activities. Here we show both that biologic isotopic fractionation signatures can be well-preserved in microfossils and that the instrumental development has reached a milestone in being able to measure such signals accurately. We also demonstrate that abiotic signatures are strongly deviated from the biological signatures, pointing out the eligibility of using stable isotopes of B, C, S, and Ni as biosignatures together with other bio-relevant metals.