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Investigation of micrometre-sized fossil by laser mass spectrometer (LMS) designed for in situ space research

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Search for signatures of life on other planets is one of the most important goals of current planetary missions. Among various possible biomarkers, which can be investigated in situ on planetary surfaces, the detection of bio-relevant elements in planetary materials is of considerable interest and the abundance of isotopes can be important signatures of past and present bioactivities [1, 2].

We investigate the chemical composition of fossilised biological inclusions embedded in a carbonate host phase by a miniature laser ablation mass spectrometer (LMS) [3]. The LMS instrument combines a laser ablation ion source for ablation, atomisation and ionisation of surface material with a reflectron time-of-flight (TOF) mass spectrometer. LMS delivers mass spectra of almost all elements and their isotopes. In the current setup a fs-laser ablation ion source is applied with high lateral (15 um) and vertical (sub-um) resolution [4, 7] and the mass analyser supports mass resolution of 400–500 (at 56Fe mass peak) and dynamic range of eight orders of magnitude [5, 6].

From the 200 mass spectra recorded at 200 different locations on the carbonate sample surface, five mass spectra were identified which recorded the chemical composition of inclusions; from the other mass spectra the composition of the carbonate host matrix could be determined. The microscopic inspection of the sample surface and correlation with the coordinates of the laser ablation measurements made the confirmation to the location of the inclusion [8]. For the carbonate host matrix, the mass spectrometric analysis yielded the major elements H, C, O, Na, Mg, K and Ca and the trace elements Li, B and Cl. The measurements at the inclusion locations yielded in addition, the detection of F, Si, P, S, Mn, Fe, Ni, Co and Se. For most of the major elements the isotope ratios were found to be conform to the terrestrial values within a few per mills, while for minor and trace elements the determination of isotope ratios were less accurate due to low signal to noise ratios (SNR). The isotope abundances for the lightest isotope of B, S were observed to be larger than terrestrial, which is consistent with isotope fractionation by bio-relevant processes and a salty ocean. The studies demonstrates the current performance of the miniature LMS for in situ investigation of highly heterogeneous samples and its capabilities for the identification of fossilised biological matter.

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