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Chemical analysis of Permafrost samples using a miniature LIMS system designed for in situ chemical analysis of solids on planetary surfaces

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The detection of extinct or extant life on planetary surfaces is of high interest to planetary research. Mars is, due to its history, one of the most promising planetary objects to find traces of life, potentially in its sub-surface. However, due to the harsh environmental conditions at which instrumentation is typically operated on a planetary surface the detection thereof becomes extremely challenging. Therefore, simple and robust instrumentation with improved figures of merit and extended measurement capabilities are of high interest for future space exploration missions. In this contribution the measurement capabilities of our miniature laser ablation ionisation mass spectrometer (LIMS) system is demonstrated, on the basis of measurements conducted on Mars-relevant analogue material.

The LIMS instrument is designed for quantitative and sensitive chemical (elements and isotopes) in situ analysis of the solids on planetary surfaces [1-3]. It consists of a miniature reflectron-type time-of-flight (RTOF) mass analyser (160 mm x Ø 60 mm) to which a femtosecond laser system (λ = 775 nm, τ ~190 fs, pulse energy $\leq$ 1 mJ) is coupled for ablation and ionisation of sample material (laser ablation craters with diameter of about 10 – 20 μm) [1].

The Mars analogue materials used in this study are permafrost samples with a high abundance in biomass that were collected at different depths (~0.5 m, ~1.5 m, ~3.0 m) of an unique surface position in the Yedoma region, Russia. To develop an optimal measurement protocol, we conducted parametric studies on the samples, including the application of various laser irradiances and number of applied laser shots per single surface position. Furthermore, part of the sample material was heated up (3 h, > 100°C) i) to investigate the impact of heat on the chemical composition of such materials and ii) to cross-check if the LIMS system is sensitive enough to identify modifications in the chemical composition. One of the major findings in this campaign was, that the carbon content was highly reduced relative to the other detected species. Measurements conducted on both the raw and heat-treated sample material are discussed in detail and compared with each other.

References:

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