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DETECTION OF MINOR AND TRACE ELEMENTS BY LASER-INDUCED BREAKDOWN SPECTROSCOPY UNDER SIMULATED MARTIAN CONDITIONS

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Introduction: Methodical investigations of Martian analogue materials under simulated Martian conditions are carried out with a Laser Induced Breakdown Spectroscopy (LIBS) spectrometer at the DLR Institute of Planetary Research. The main objective is to deliver useful input for the calibration of the combined Raman and LIBS spectrometer, which is part of the scientific rover payload of the ExoMars mission, to be launched in 2013 [1, 2]. A number of detailed studies concerning different parameters influencing the LIBS signal detection under Martian conditions have been published [see, for example, 3-6]. Because of the limitations of mass and energy, the LIBS spectrometer on the ExoMars mission will have to operate at low repetition and ablation rates and it is probably not possible to provide the same spectral resolution as in laboratory conditions. The presented study focuses on identification of minor and trace elements in the LIBS spectra from volcanic rock materials under Martian conditions and for relatively low laser excitation energies.

Experimental: The LIBS spectrometer in DLR-Berlin is capable to carefully reproduce the experimental conditions expected on the Mars surface and for the LIBS instrument. The special chamber keeps a 6-7 mbar of a mixed Martian-like gas atmosphere (CO_2, N_2, Ar, O_2) and temperature range of 220-290 K. The setup uses a Q-switched Nd-YAG laser (Continuum Inlite II-20) at 1064 nm with a repetition rate of 10 Hz, pulse duration of 8 ns and maximum output power of 250 mJ. The laser was focused on the sample surface in a spot of 70-80 μm. The Aryelle-Butterfly spectrometer (LTB-Berlin) utilizes a broad band (171-372 nm & 275-898 nm) high resolution (9400-14000) Echelle monochromator and a gated ICCD camera (Andor).

Results: We analysed a few Martian-like basalt rock samples and also samples pressed from the powder of the same material at the Martian atmosphere, 7 mbar and 213 K. Many minor and trace elements become to be difficult identified at laser fluencies below 100 J/cm^2 for a single (or a few) excitation pulses or at below 10 J/cm^2 for LIBS signals integrated over 30-50 laser shots. The signal-to-noise ratio significantly drops down for the spectra averaged over less than 10-20 laser shots (Fig. 1). Relative line intensities for different elements vary significantly for the rock samples (Fig. 2). LIBS spectra at Martian conditions demonstrate a non-negligible background signal decaying at times longer than a few hundreds of ns.

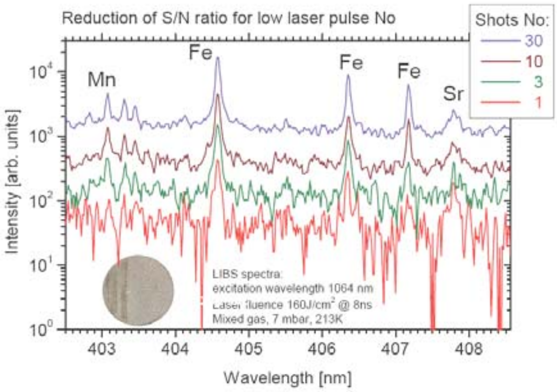

Figure 1. Examples of the LIBS spectra for the Basalt-Vogelsberg rock samples for different number of the laser excitation shots. ICCD delay and gate 300 ns and 50 μs.

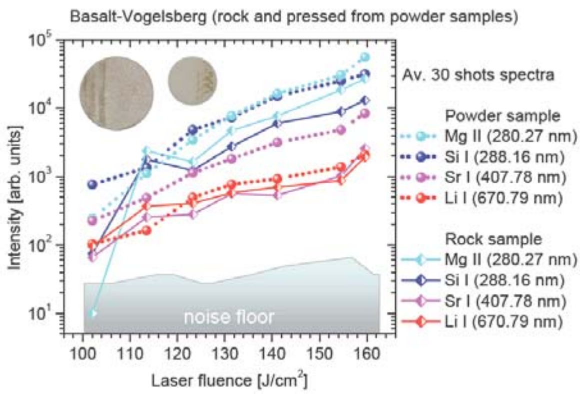

Figure 2. Comparison of the LIBS line intensities for the Basalt-Vogelsberg rock and pressed from the powder (density of 2 g/cm^3) samples. Excitation power on the sample surface was 7 mJ. ICCD camera delay was 300 ns and gate was 50 μs. Signal is averaged over 30 laser shots.

References: [1]. See the ESA's homepage for the AURORA ExoMars mission: www.esa.int/specials/Aurora/SEM1NVZKQAD_0.html.
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