EPSC Abstracts
Vol. 6, EPSC-DPS2011-809, 2011
EPSC-DPS Joint Meeting 2011

Analysis of geological samples by laser-induced breakdown spectroscopy at low atmospheric pressures

S. G. Pavlov (1), S. Schröder (1), E. K. Jessberger (2) and H.-W. Hübers (1,3)
(1) Institute of Planetary Research, German Aerospace Center, Berlin, Germany, (2) Institut für Planetologie, Westfälische-Wilhelm-Universität, Münster, Germany, (3) Institut für Optik und Atomare Physik, Technische Universität Berlin, Germany (sergeij.pavlov@dlr.de / Fax: +49-30-67055507)

Abstract

Several future space missions to planets, moons and asteroids in the solar system consider landers equipped with a laser-induced breakdown spectroscopy (LIBS) instrument. This technique provides an in-situ elemental analysis of all major and many trace elements on surfaces of the solar system bodies by identification of particular atomic transitions in emission spectra of laser-induced plasmas. Excitation and evolution of the plasma depends strongly on the environmental pressure [1]. Therefore, the capability of LIBS is studied for each individual space mission. We focus on LIBS at ultra-high vacuum for exploration of solar system bodies with thin atmospheres and demonstrate its usefulness at a pressure >1 mPa and with a laser excitation energy >1 mJ.

LIBS at ultra-low pressure

At low pressures, excited plasmas have smaller plumes and expand rapidly. To overcome these limitations one requires usually a relatively powerful laser source for plasma generation [1-3]. We focused on the study of LIBS emission spectra with a miniaturized low-energy laser (Nd:YLF, 1053 nm, 2.7 mJ, 2 ns), developed for future planetary missions. We used several basaltic rock and sediment standard materials first crashed into powder and then pressed into pellets. Despite a significant reduction of the number of observed atomic lines at pressures <1 mPa, the excitation energy of ~1 mJ from the laser (power density on the sample ~20 MW/mm^2) remains sufficient for plasma generation with detectable atomic emission lines (Fig. 1) of elements with relative weight abundance above 10^{-3}. Reduction of pressure and broadening of spectral lines compensates partly the decrease in signal-to-noise ratios for light elements and doublet/triplet atomic transitions.

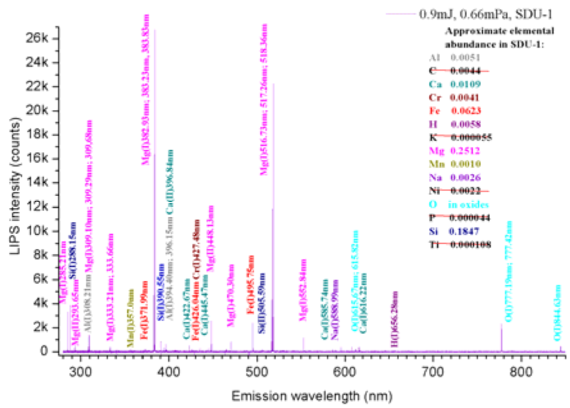

Figure 1: LIBS spectrum obtained Dunite SDU-1 at a pressure of 0.66 mPa. Laser pulse energy is 0.9 mJ. Bars on the right show observed elements and their relative abundance in the sample.

Acknowledgements

This work was partly supported by Helmholtz-Gemeinschaft Deutscher Forschungszentren (HGF) Alliance "Planetary Evolution and Life".

References

[1] Knight, A. K., Scherbarth, N. L., Cremers D. A. and Ferris, M. J.: Characterization of laser-induced breakdown spectroscopy (LIBS) for applications to space exploration, Appl. Spectrosc. Vol. 54, pp. 331–340, 2000.

[2] Harris, R. D., Cremers, D. A., Khoo, C. and Benelli, K.: LIBS-based detection of geological samples at low pressures (<0.0001 Torr) for Moon and asteroid exploration. LPSC XXXVI, Abstract#1796, 2005.

[3] Lasue, J., Wiens, R. C., Clegg, S. M., Vaniman, D. T., Joy, K. H., Humphries, S.: Applicability of LIBS on the Moon: Elemental analysis of lunar simulants in vacuum. LPSC XXXXII, Abstract#1165, 2011.