Geophysical Research Abstracts
Vol. 14, EGU2012-12577-1, 2012
EGU General Assembly 2012

A miniaturised laser ablation/ionisation analyser for investigation of elemental/isotopic composition with the sub-ppm detection sensitivity

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Detailed knowledge of the elemental and isotopic composition of solar system objects imposes critical constraints on models describing the origin of our solar system and can provide insight to chemical and physical processes taking place during the planetary evolution. So far, the investigation of chemical composition of planetary surfaces could be conducted almost exclusively by remotely controlled spectroscopic instruments from orbiting spacecraft, landers or rovers. With some exceptions, the sensitivity of these techniques is, however, limited and often only abundant elements can be investigated. Nevertheless, the spectroscopic techniques proved to be successful for global chemical mapping of entire planetary objects such as the Moon, Mars and asteroids. A combined afford of the measurements from orbit, landers and rovers can also yield the determination of local mineralogy. New instruments including Laser Induced Breakdown Spectroscopy (LIBS) and Laser Ablation/Ionisation Mass Spectrometer (LIMS), have been recently included for several landed missions. LIBS is thought to improve flexibility of the investigations and offers a well localised chemical probing from distances up to 10–13 m. Since LIMS is a mass spectrometric technique it allows for very sensitive measurements of elements and isotopes.
We will demonstrate the results of the current performance tests obtained by application of a miniaturised laser ablation/ionisation mass spectrometer, a LIMS instrument, developed in Bern for the chemical analysis of solids. So far, the only LIMS instrument on a spacecraft is the LAZMA instrument. This spectrometer was a part of the payload for PHOBOS-GRUNT mission and is also currently selected for LUNA-RESURCE and LUNA-GLOB missions to the lunar south poles (Managadze et al., 2011). Our LIMS instrument has the dimensions of 120 x Ø60 mm and with a weight of about 1.5 kg (all electronics included), it is the lightest mass analyser designed for in situ chemical analysis of solid materials on the planetary surfaces (Rohner et al., 2003). Initial laboratory tests that were conducted with an IR laser radiation for the ablation, atomisation and ionisation of the material, indicated a high performance of the instrument in terms of sensitivity, dynamic range and mass resolution (Tulej et al., 2011). After some technical improvements and implementation of a computer-controlled performance optimiser we have achieved further improvements of both, the instrumental sensitivity down to sub-ppm level and reproducibility of the measurements. We will demonstrate the potential of the mass analyser to perform the quantitative elemental analysis of solids with a spatial (vertical, lateral) resolution commensurate with typical grain sizes, and its capabilities for investigation of isotopic patterns with accuracy and precision comparable to that of large analytical laboratory instruments, e.g., TIMS, SIMS, LA-ICP-MS. The results can be of considerable interest for in situ dating or investigation of other fine isotopic fractionation effects including studies of bio-markers.

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