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Chemical and mineralogical analyses of planetary rocks using a laser ablation mass spectrometer for in situ space research

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The context chemical analysis is of considerable importance in space research. High resolution in situ studies of planetary materials can yield important information on surface heterogeneity, basic grain mineralogy and chemical composition of surface and subsurface. In turn, these data are the basis for our understanding of the physical and chemical processes which led to the formation and alteration of planetary material [1] [2].

A highly heterogeneous sample of Allende meteorite, representative for extraterrestrial material, is investigated by LMS, a miniature laser ablation mass spectrometer designed for space research [3]. In the current setup a fs-laser ablation ion source is applied, allowing chemical analysis with lateral resolution of about 10-15 μm and sub-micrometre depth resolution [4]. The reflectron TOF mass analyser is used to measure elemental and isotopic composition of the sampled surface. The LMS instrument supports mass resolution 400 and dynamic range of 10^8 [5]. In the current studies with the fs-ablation ion source significant improvements in the detection efficiency of several metals e.g., Ni, Co, and non-metals e.g., Si, P, S and O, was achieved comparing to our previous setup [6]. Also the values of sensitivity coefficients for these elements are determined to be close to one, which resulted in the substantial improvements of the quantitative element analysis of the sample. Since the ablation crater depth is expected to be about 1 nm/laser shot also the possible changes of the main element or isotope distribution in depth can be analysed to assess their influence on the mineralogical analysis [7].

Several areas on an Allende sample were investigated and the chemical composition across the surface was determined from the mass spectrometric analysis. Also accurate isotope analysis could be conducted for most of main elements with sufficiently high signal to noise ratio.

Correlation of elements was conducted and yielded mineralogical maps. With the current spatial resolution, grain-sized inclusions embedded in the surface (e.g. CAIs, dark inclusions, metal grains) could be identified. Detailed investigations, e.g. differentiation of chondrule components from rims of chondrules can be derived from LMS data.

LMS has capabilities for highly sensitive chemical composition measurements of grain sized inclusions and sub-micrometre sized surface layers. The latter information is of considerable interest in the context of space weathering.

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