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UTILIZING LASER-INDUCED BREAKDOWN TECHNOLOGY FOR THE IDENTIFICATION AND QUANTIFICATION OF VOLATILES IN LUNAR REGOLITH

Abstract

Quantifying volatiles in the surface and subsurface lunar regolith is a major scientific objective of upcoming robotic missions on the Moon. Although water ice detection has been allowed by remote-sensing data during the past decades, the accuracy of abundance estimations is limited by spatial resolution. For instance, direct observations of H_2O led using data acquired with the Moon Mineralogy Mapper have a pixel size of 280m [1]. In-situ spectrometry data is therefore an important step towards a more accurate evaluation of the local distribution of volatiles such as water ice. In this instance, Laser-Induced Breakdown Spectroscopy (LIBS) capabilities for the quantification of volatiles within regolith simulants are studied. LIBS has gained interest within the planetary science community thanks to its high autonomy and versatility for the analysis of chemical compositions of geologic materials. Two LIBS instruments are also currently mounted on rovers Curiosity and Perseverance surveying the Martian surface.
LIBS measurements were conducted on icy lunar regolith simulants. Preprocessing applied to this dataset solely include dark correction and baseline correction for H peak extraction. Different multivariate regression models are used to assess the abundance of H_2O within such samples. RMSEP of ice abundance estimations are compared to evaluate the predictive performance of those methods. Data acquired as of now show that LIBS intensity at 656.5nm is linearly dependent to water ice concentration within the sample below approximately 10wt.%. A linear model would therefore be sufficient to quantify an H_2O abundance of 5.6wt%, which was previously estimated using spectrometry data of the LCROSS impact in Cabeus crater [2]. Measurements conducted on regolith simulants of varying compaction also show a very high sensitivity of LIBS intensity to bulk density, with a 160% increase of the mean spectral emission for a simulant tableted with a weight of 20tons. Hyperspectral cubes of emission intensity can thus be analyzed to evaluate hydration and bulk density distribution within a sample. LIBS images allow to overcome sample's heterogeneity at the pixel scale as a single acquisition comprises up to 250'000 measurements with a spatial resolution of 50 μm, leading to high repeatability of the average spectral intensity when experimental conditions are kept constant. Particles and clumps of diameter larger than laser stepsize value may also differentiated using such a technique.
[1] Li, S. et al. (2018) PNAS 115 (36) 8907-8912.
[2] Colaprete, A. et al. (2010) Science 330 (6003), 463-468.