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# Martian library of LIBS emission lines

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## Abstract

ChemCam is an active remote sensing instrument using the Laser Induced Breakdown Spectroscopy (LIBS) technique and micro-imaging (RMI) to investigate details of the Martian surface geochemistry [1, 2]. It is part of the Mars Science Laboratory (MSL) rover payload, scheduled for launch in fall of 2011. ChemCam's key innovation is to perform LIBS analysis at remote distances, from 1 to 7 meters. The objectives of this work is to present the library of emission lines under Martian environment realized with our experiment, and to present its applications and our perspectives.

## 1. Introduction

ChemCam is an instrument in two parts: the "Mast Unit" (procured by France), located at 2 m height on top of the remote sensing mast, the "Body Unit" (procured by USA), in the core of the rover. The Body and Mast units are connected by a 6 m long optical fiber. An array of calibration targets is located on the rover. The Mast-Unit comprises a high power laser, a telescope to focus the laser beam onto a target and to collect the plasma light, a micro-imager to obtain context data, and an electronic box. The body Unit consists of a demultiplexer, three spectrometers, front-end analog electronics for the spectrometer CCDs, and a digital unit that operates the whole instrument and interfaces with the rover.

The general purpose of our work is to study spectra of rocks acquired under Martian conditions, to simulate expected data we could have once the instrument is on the Martian surface. Such laboratory data will be used to develop peak identification tools, as well as statistical tools, like the ones used in library of emission lines realized with our experiment for major/minor elements under Martian environment, and then the perspectives we have.

## 2. Martian library of LIBS emission lines

We performed a library of all LIBS emission lines observed for each element, under Martian environment. It was necessary to realize this work because the most comprehensive database, NIST [4] is not dedicated to LIBS, and exists under ambient and vacuum environments, but not under Martian atmosphere. The effect of pressure is to offset the spectral band, to enlarge the lines, and to increase the signal-to-noise ratio [5]. Another dedicated database for LIBS exists [6] but not appropriate for Mars environment.

### 2.1 Experimental Setup

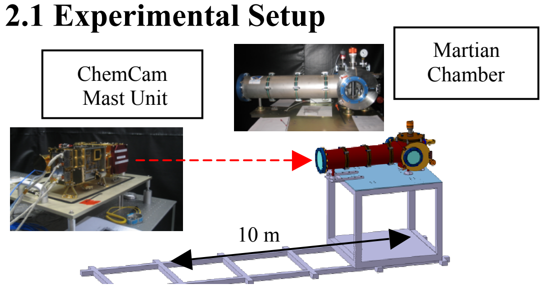


Figure 1: Schematic and pictures of the instrument and of the Martian chamber.

The instrument used for our work is the Engineering and Qualification Model (EQM) of ChemCam for the Mast Unit, which is similar to the flight model. In place of the Body Unit, we used three commercial-grade spectrometers from Ocean Optics and a single fiber that is alternatively connected to each of them. Hereafter, the spectrographs are denominated UV (239-340 nm), VIS (384-471 nm), and VNIR (494-930 nm). See [3] for details. We used only "pure" targets of major or minor elements, such as sheets of Aluminum, Silicon, Magnesium, etc, since the aim of this work was to create a library of emission lines of major/minor elements, under Martian environment. These targets were placed in the Martian chamber in which the Martian atmosphere is reproduced (5-10 mbar, 95.7% $CO_2$, 1.6% Ar, 2.7% $N_2$). This chamber is elongated along the axis of the laser beam to avoid focusing on the window, and is mounted on a track (1 m to 10 m) to simulate the instrument/target distance

## 2.2 Data Analysis and Peak identification

By fitting the lines of spectra from elements under Martian environment and comparing the position observed with the NIST database, it was possible to create a library of elemental emission lines meaningful for our instrument, under Martian atmosphere (Figure 2). For each element, this new database gives the observed wavelength, the matching wavelength from the NIST database with its relative intensity, the observed intensity, and the level of energy.

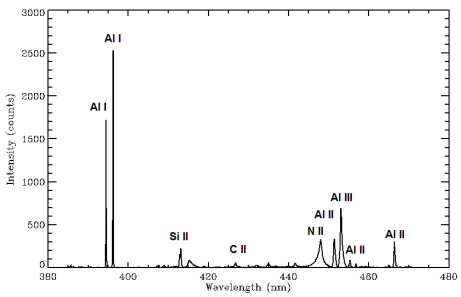


Figure 2: Example of the peak identification (element and ionization levels) for an Aluminum/Silicon target, under Martian environment (VIS spectrum).

# 3. Applications and Perspectives

This database will be an important component of the ChemCam data processing tool, and a reference for people who work with the LIBS technique under Martian conditions. Several applications are foreseen: i) we have to develop a tool to visualize emission lines of interest from the database. This will permit to localize precisely the most important emission lines from each element, ii) this database is useful to perform peak identification for complex rocks under Martian environment (Figure 3).

Our perspectives are to create a library of LIBS spectra of specific rocks, under Martian conditions. With regard of rocks, spectra are much more complex than “pure targets”, but they nevertheless rely on non-linear combinations of appropriate “pure target” spectra. Besides, the ratios within rock spectra are not equivalent to ratios within the corresponding “pure target” spectra, because of matrix effects [7]. The first step consists to analyze typical minerals of magmatic rocks, like pyroxenes, feldspaths, and olivine. The second step consists to analyze magmatic rocks, specifically rocks with similar compositions than those observed on Martian surface by the Martian Exploration Rover (MER) (Figure 4).

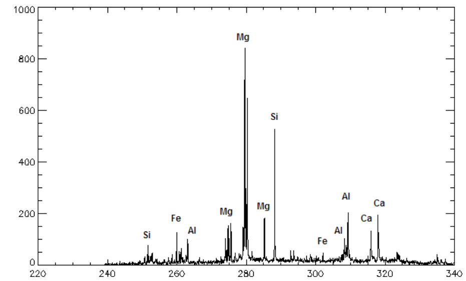


Figure 3: Example of the peak identification for an aphanitic basalt under Martian environment (UVspectrum).

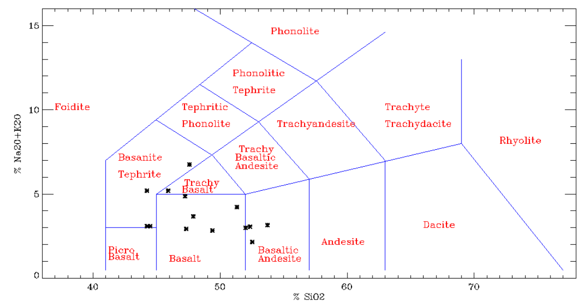


Figure 4: TAS (“Total Alkali Silica”) diagram with rocks we are analyzing by LIBS under Martian environments (black crosses).

# 4. Summary

In conclusion, we performed a library of elemental emission lines under Martian conditions with the LIBS technique. Now, the objectives are to use this database to analyze volcanic rocks under the same environment. Rocks acquisition is done, and data acquisition is still in progress. Then, it could be possible to develop statistical tools like PCA/ICA to classify them for further quantitative analysis [8].

# References

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