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ChemCam analysis of martian fine dust

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Abstract

ChemCam detects a specific dust contribution on every first shot of LIBS analysis. The pure elements calibration targets on-board are used to retrieve the chemical composition signal of this dust.

1. Introduction

ChemCam stands for Chemistry Camera and is a Laser-Induced Breakdown Spectroscopy (LIBS) instrument on-board the NASA Curiosity rover currently exploring Mars. This technique enables the MSL team to measure the chemical composition of geological samples without preparation and at a distance from the rover (2 to 7 m) by collecting the light emission of constituent elements [5, 9]. For every target, a single shot removes few ng of material. Since the beginning of the mission, ChemCam has analyzed from 30 to 600 shots per target. In every case, the first few shots (less than five) present a composition characteristic of the global martian fine dust, which covers the entire planet and contributes to the local geology analyzed by MSL [6, 10]. This work shows how ChemCam data on pure elemental calibration targets can be used to retrieve and analyze in detail this fine dust elemental composition.

2. Martian fine dust component

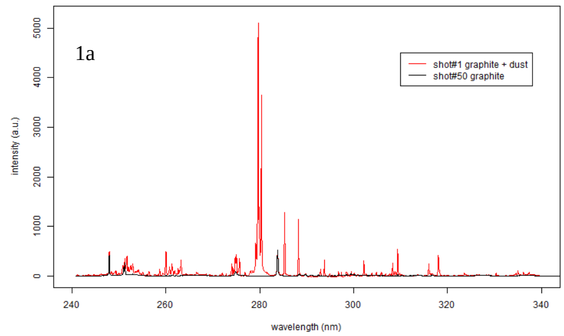
2.1 The first ChemCam shot

From the beginning of the mission, every first shot analyzed by ChemCam has presented a significant compositional contribution, always identical, that is representative of a global martian component. While this contribution is routinely removed from the analysis of the targets of ChemCam, it can also be used to infer properties of the global regolith of Mars. One way to do so is to use the well characterized ChemCam calibration targets on-board the rover, which include titanium and graphite samples [3, 8], to retrieve the composition of this dust component. One advantage of this approach is that its airborne origin and recent deposition are known, and its typical grain size well constrained (around 1-2 µm [e.g. 2]). This airborne origin is also evidenced by the thickness variations of this layer with time: while this composition was present in just the first shot on graphite on sol 27, it was detected in the first 3 shots on sol 76. This ensures that this dust is not indurated or altered, as it could be on rocks. The interpretation that this dust component is a global one is consistent with its detection on every ChemCam target.

2.2 Martian fine dust component from the 'pure' elemental calibration targets

The ChemCam onboard calibration targets include eight glasses and ceramics that have been generated to simulate Martian rocks of interest [3, 8]. Two 'pure' elements targets were added, one of titanium and the other of graphite. While these targets are routinely used to assess the instrument health, their chemical compositions are significantly different from the martian dust cover, which allows us to retrieve the LIBS spectrum of the first layer of the targets which is dominated by the martian dust. This is especially true of the graphite calibration which presents much fewer lines of emission than the Ti calibration target, even though it can mask the atmospheric C lines.

Figure 1a shows the superposition of the first and 50th shot taken on the graphite calibration target over the UV range. The two main lines of emission of C in the UV (CI 247.9nm and CII 283.8nm) are visible in both spectra. The first spectrum clearly presents all the other major elements (Fe, Si, Mg, Al, Ca, Ti) that are absent from a clean C spectrum [5, 9].



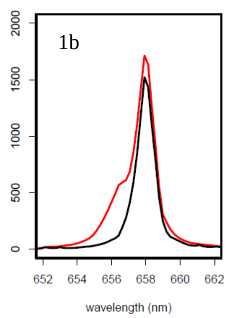


Figure 1a and 1b: comparison of the first and last ChemCam analysis shot on the graphite calibration target.

The image 1b at left shows the presence of the H line at 656nm.

This can be used to retrieve the dust contribution to the first spectrum, assuming no C is present other than the atmospheric contribution. In each spectral range, a C emission line is selected so that it does not overlap with other emission lines of the dust spectrum, and is not present in the spectra analyzed on other targets on Mars. Such lines can be used to determine the ratio by which to multiply the clean C spectrum to remove the C lines contribution from the first dust spectrum taken on the target. CII 283.8nm; CII 426.8nm and CII 678.6nm are used and their ratio in each case is coherent and calculated to be around 1.4.

3. Discussion of the results

The dust spectrum retrieved in this manner still contains a contribution from the atmosphere, seen in the remaining C lines. All the major elements can be seen. The line ratios are consistent with a basaltic composition similar to the one detected globally on the planet [2, 5, 10]. A strong H contribution is detected in every ChemCam first shot (e.g. Figure 1b), indicating that this fine dust is a contributor to the H content of the martian samples also detected by the SAM and Chemin instruments [1, 4], meaning that this fine dust also contains part of the hydrated amorphous phase of the soil [1]. While H is clearly present, work is on-going to quantify its exact content [7]

Comparison between the fine dust component and typical soils such as Crestaurum (sol 74) or Portage (sol 89), indicates a similar content in Fe, Mg, Si and H and a higher content in Ca and K, consistent with previous works [see e.g. 6]. Quantitative assessments of the composition and detection of minor elements will be presented.

Acknowledgements

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References

[1] Blake, D., Bish, D., Morris, R. et al.: Mineralogy and elemental composition of wind drift soil at rocknest, Gale crater, 44th Lunar Planet. Sci. Conf., #1289, 2013.

[2] Clancy, R., Wolff, M., Christensen, P.: Mars aerosol studies with the MGS TES emission phase function observations, J. Geophys. Res., 108, E9-5098, 2003.

[3] Fabre, C., Maurice, S., Cousin, A. et al.: Onboard calibration igneous targets for the Mars Science Laboratory Curiosity rover and the ChemCam LIBS instrument, Spectrochim. Acta, Vol. 66, pp. 280-289, 2011.

[4] Leshin, L., Grotzinger, J., Blake, D. et al.: Integrated results from analysis of the rocknest Aeolian deposit by the curiosity rover, 44th Lunar Planet. Sci. Conf., #1774, 2013.

[5] Maurice, S., Wiens, R., Saccoccio, M. et al.: The ChemCam instrument suite on the Mars Science Laboratory (MSL) rover: science objectives and mast unit description, Space Sci. Rev., Vol. 170, pp. 95-166, 2012.

[6] Meslin, P-Y., Cousin, A., Berger, G. et al.: Soils diversity along Bradbury-Glenelg traverse, 44th Lunar Planet. Sci. Conf., #2023, 2013.

[7] Schröder, S., Meslin, P.-Y., Cousin, A., et al.: Hydrogen in soils and dust as observed in ChemCam spectra at Gale Crater, Mars., EGU 2013, #11858, 2013.

[8] Vaniman, D., Dyar, D., Wiens, R. et al.: Ceramic ChemCam calibration targets on Mars Science Laboratory, Space Sci. Rev., Vol. 170, pp. 229-255, 2012.

[9] Wiens, R., Maurice, S., Barraclough, B. et al.: The ChemCam instrument suite on the Mars Science Laboratory (MSL) rover: Body unit and combined system tests, Space Sci. Rev., Vol. 170, pp. 167-227, 2012.

[10] Wiens, R., Maurice, S., Sautter, V. et al.: Compositions determined by ChemCam along Curiosity's traverse from Bradbury Station to Glenelg in Gale crater, Mars, 44th Lunar Planet. Sci. Conf., #1363, 2013.