CHEMCAM ANALYSIS OF MARTIAN FINE DUST, J. Lasue[1], S. Maurice[1], A. Cousin[2], O. Forni[1], P.-Y. Meslin[1], W. Rapin[1], S. Schroeder[1], A. Ollila[3], G. Berger[1], N. Bridges[4], S.M. Clegg[2], C. D'uston[1], C. Fabre[5], O. Gasnault[1], W. Goetz[6], J. Johnson[4], N. Lanza[2], S. Le Mouélic[7], M. B. Madsen[8], N. Mangold[7], N. Melikechi[9], A. Mezzacappa[9], H. Newsom[3], R.C. Wiens[2], and the MSL Science team.
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Introduction: ChemCam is a Laser-Induced Breakdown Spectroscopy (LIBS) instrument on-board the NASA Curiosity rover currently exploring Mars. ChemCam can analyze the chemical composition of geological samples without preparation and at a distance by detecting the light emission of constituting elements [1, 2]. For every target, a single shot removes few ng of material. Up to sol 359, the instrument successfully acquired 79140 spectra. 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 [3] and contributes to the local geology analyzed by MSL [4, 5]. This work shows how ChemCam data on single element calibration targets can be used to retrieve and analyze in detail the fine dust chemical composition.

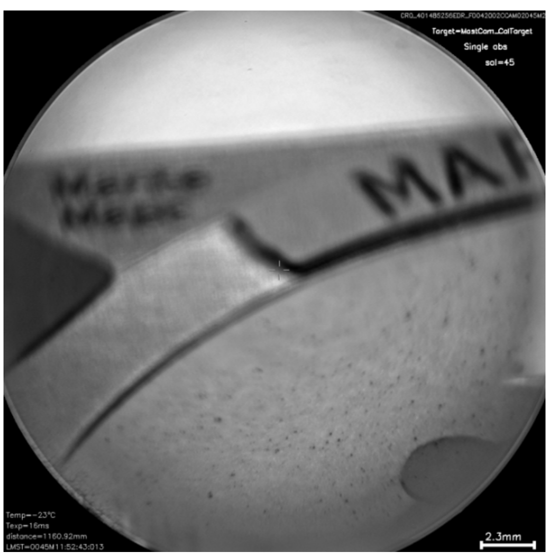

Figure 1:ChemCam RMI image of dust covering the MastCam calibration target on sol 45. Large particles are mostly clumps of smaller grains.

Martian fine dust cover on the targets: A global component of fine dust aerosol can be mobilized by eolian processes on the surface of Mars and deposits constantly on the Mars rovers. As shown in Figure 1, very small dust particles were already present on the Mastcam calibration target after one month of operations on the surface of Mars. In analyzing this dust component, we ascertain its airborne origin and recent deposition, and ensure that the typical grain size is well constrained (around 1-2 µm [e.g. 6]).

ChemCam passive spectroscopy [7] has also been used to assess the variations in dust cover from the rover paint target located amongst the ChemCam calibration targets (CCCT). The passive spectroscopy presents a reddening of the rover paint CCCT with time that indicates a progressive deposition of the dust particles on its surface.

The first ChemCam shot: Since 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. This contribution, appearing in the first five shots, is routinely removed from the analysis of the targets of ChemCam to get the composition of the underlying rock [8]. The consistency of this first spectrum gave the opportunity for the ChemCam team to improve the distance correction for the ChemCam data [9, 10].

The martian fine dust component composition can be retrieved by using the well characterized ChemCam calibration targets (CCCT) on-board the rover. The CCCT include eight glasses and ceramics that have been generated to simulate Martian rocks of interest [11, 12]. Two calibration targets constituted mostly of a single element were added, one of graphite (C), and the other, an alloy of titanium (Ti, ~6% Al and Va).

The airborne origin of the dust is 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, and in the first 5 shots of the analyses done on sols 192 and 359. This ensures that this dust is not indurated or altered, as it could be on rocks.

Martian fine dust composition from the single element calibration targets: The CCCT are routinely used to assess the instrument health and aging. 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 CCCT which presents much fewer lines of emission than the Ti calibration target, even though it can mask the atmospheric C lines.

Figure 2 shows the superposition of the first and last shots taken on the graphite calibration target over the UV range on sol 27. 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 typical carbon spectrum (in black).

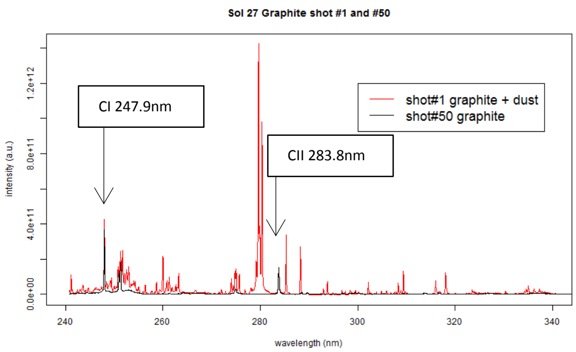

Figure 2: Comparison between the first and last chemcam analysis shots on the graphite calibration target of sol 27.

The comparison between the first and last spectra on the graphite can be used to derive the chemical composition of the dust layer on the target, assuming no C is present other than the atmospheric contribution. In each spectral range, we select C emission lines which do not interfere with any other spectral line present on other martian targets. Such lines can be used to normalize the clean C spectrum in order to remove the C lines contribution from the first spectrum contaminated by dust spectrum. The lines of CII 283.8nm; CII 426.8nm and CII 678.6nm are used and their respective ratios are in each case consistent and calculated to be around 1.4.

Discussion of the results: The dust spectrum retrieved in this way is consistent over the whole year of Mars exploration, for which 4 observations on the graphite CCCT have been made (sol 27, 76, 192 and 359). All the major and some minor elements are detected. The line ratios are consistent with a basaltic composition similar to the one detected globally on the planet [3-6]. Every ChemCam first shot presents a strong H line, indicating that this fine dust is a contributor to the H content of the martian samples also detected by the SAM and Chemin instruments [4, 13]. This in turns means that this fine dust also contains part of the hydrated amorphous phase of the soil [4]. While H is clearly present, work is on-going to quantify its exact content [14]

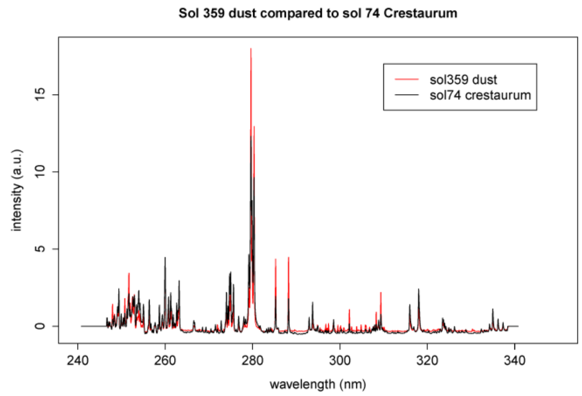

Figure 3: Comparison between the analysis of Crestaurum soil (sol 74) and the dust spectrum retrieved from the graphite CCCT (sol 359).

As shown in Figure 3, comparison between the fine dust component and typical fine soils such as Crestaurum (observed on sol 74), indicates a similar content in Fe, Mg, Si, Ti, Al and H and a higher content in Ca and K, consistent with previous works [see e.g. 5]. The minor elements Ba, Cr, Sr, and Mn are detected in quantities similar to previous soils analyses (such as Crestaurum and Portage (sol 89)). Li is detected at a level 3 times larger than the typical soil. Sulfur may be detected. The composition of the dust will be quantified and compared to ChemCam targets.

Conclusion: We have demonstrated that the chemical composition of the martian fine dust component constantly deposited on the surface of the rover can be analyzed with the ChemCam instrument. ChemCam renews the knowledge of Martian fine dust by assessing in details its chemistry and its hydration state.

Acknowledgments: Support from the French Space Agency (CNES) and NASA's Mars Program Office are acknowledged.

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