P29

Plasma-atmosphere interactions in Martian LIBS and implications for carbonate characterization

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Three LIBS instruments have successfully been deployed on Mars so far: ChemCam onboard NASA's Curiosity rover (2012-ongoing) [1-2], SuperCam onboard NASA's Perseverance rover (2021-ongoing) [3-4], MarsCode onboard the Chinese Zhurong rover (2021-2022) [5], providing chemical information for thousands of targets on three areas around Mars. One challenge with LIBS on Mars is to characterize the carbon-content of a sample, since the Martian atmosphere (~6 mbar of CO_2) contributes some C and O signal in all LIBS spectra [6-11]. We aim to characterize the plasmaatmosphere interactions and **atmospheric contribution to the carbon signal in Martian LIBS spectra**.

We use **temporally and spatially resolved plasma observations** to study the dynamics of carbon in the plasma depending on the origin of the carbon: either the sample or the atmosphere. Using the setup from DLR-WR-ISS, Berlin [12-13], we image the C I 248 nm, C II 251 nm, O I 777 nm and O II 689 nm emission lines. Measurements are performed in 6 mbar of Martian atmospheric simulant (96% CO_2) or 6 mbar of air (for comparable plasma development), on pellets of pure graphite, Mg-carbonate and Mg-sulfate, respectively.

We will show that the atmospheric C and O content contributes significantly to plasma's C I and I emissions, influencing the intensity of the investigated emission lines, as well as the spatial distribution of these species with the plume. In particular, C I from the sample appears to remain in the central region of the plasma, whereas atmospheric C I is located in a thick envelope farther out (Fig. 1). For the signals of C II and O II, which remain close to the plasma center in all configurations, the difference is mostly in signal lifetime.

We will discuss the implications of our findings for carbon characterization in geological targets on the surface of Mars.

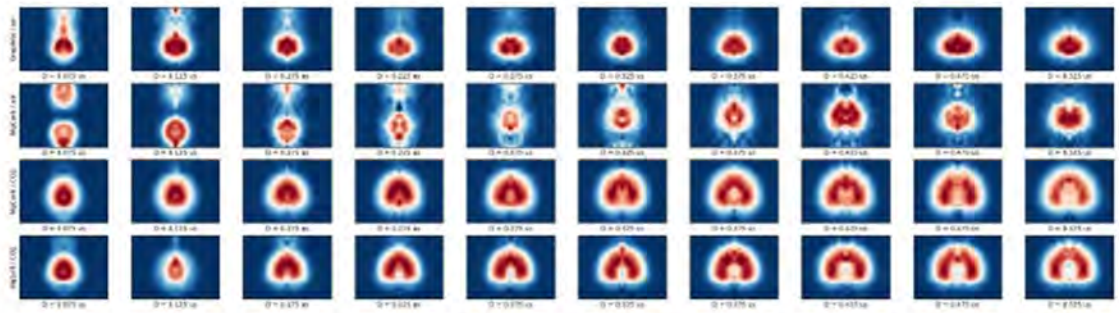

Fig. 1 Plasma imaging of C I 248 nm in 4 experimental configurations (P = 6-7 mbar): Graphite in air; Mgcarbonate in air; Mg-carbonate in CO2; Mg-sulfate in CO2. The acquisition gate is 50 ns and the delay increased in the time series with 50 ns steps; 10 shots are accumulated for each image. The images were cropped, stitched (2 heights), smoothed and Abel inverted, to correct for the integration of signal along the way of sight.

Keywords: Carbon; Atmosphere; Mars; Plasma imaging.

REFERENCES: [1] Maurice et al., SSR 2012; [2] Wiens et al., SSR 2012; [3] Maurice et al., SSR 2021; [4] Wiens et al., SSR 2021; [5] Xu et al., SSR 2021; [6] Gasnault et al., 2012; [7] Beck et al., LPSC 2016; [8] Beck et al., LPSC 2017; [9] Schröder et al., Icarus 2019; [10] Clavé et al., JGRP 2023; [11] Beck et al., SAB 2024; [12] Vogt et al., SAB 2021; [13] Seel et al., Icarus 2024.