SUPERCAM'S RAMAN OBSERVATIONS DURING THE MARGIN UNIT AND CRATER RIM CAMPAIGNS. J. A. Manrique[1], E. Clavé[2], G. Lopez-Reyes[1], O. Beyssac[3], A.M. Ollila[4], O. Forni[5], L. Coloma[6], M. Veneranda[1], T. Acosta[7], J. Aramendia[6], G. Arana[6], S. Bernard[3], J. Comellas[7], E. Dehouck[8], S. Julve-Gonzalez[1], E. Kelly[7], J. M. Madariaga[6], S. Maurice[5], I. Reyes-Rodriguez[1], F. Rull[1], S. Schröder[2], S. K. Sharma[7], Z.U. Wolf[4], O. Gasnault[5], S. Clegg[4], A. Cousin[5], R. C. Wiens[9] and the SuperCam team [1]Univerisy of Valladolid (joseantonio.manrique@uva.es), [2]DLR-OS, [3]CNRS, [4]Los Alamos National Laboratory, [5]IRAP, [6] University of Basque Country, [7] University of Hawaii, [8]University of Lyon, [9]Purdue University.

Introduction: Since February 2021 the Perseverance rover has been roaming the surface of Mars, in Jezero crater. Along its traverse it has characterized the crater floor where the delta was formed, the Western Fan and after these campaigns [1]–[3] the mission started the characterization of the Margin Unit (MU), Neretva Vallis (NV) and after a steep climb, the Crater Rim (CR). Among the different instruments on Perseverance, SuperCam provides the ability to perform Laser Induced Breakdown Spectroscopy (LIBS), sound recording, high magnification imaging, VISible and InfraRed spectroscopy (VISIR), Time Resolved Raman, and Time Resolved Luminescence, all in standoff configuration. This mission pioneered the inclusion of sound recording, in-situ (VISIR) and, more related to this work, the two first Raman instruments for planetary exploration.

In this work we will focus on the Raman results of SuperCam in the latest two geological zones analyzed by Perseverance, the carbonate rich Margin Unit and the Crater Rim, generated during the impact.

Methods: SuperCam's Time Resolved Raman (TRR) uses a 532 nm pulsed laser, delivering 12 mJ to the target in a collimated beam, with a power density of 30 kW/mm^2. The analytical Field Of View (FOV) of 0.74 mrad collects the scattered photons from a 1.5 mm diameter at 2 meters. The transmission spectrometer in SuperCam collects spectra from 532 to 850 nm, or ~100 to 7032 cm^{-1} in Raman shift. Its gated detector allows, along with the synchronization with the laser, to collect spectra with gate widths down to 100 ns. Raman data are usually collected coaligned with other techniques such as LIBS or VISIR, and with an image for context.

Results in the Margin Unit (MU): This unit was characterized between sols 910 and 1159. Preliminary results from SuperCam in this geological zone were described elsewhere [4][5].

The MU has one of the strongest carbonate signature observed from orbit within Jezero and regionally [6] [7]; combined with its remarkable location along the inner rim of the crater, it has been hypothesized that carbonates in this unit might have a high astrobiological potential. SuperCam's TRR performed analyses on 19 targets, including 8 abraded patches and 11 natural surfaces.

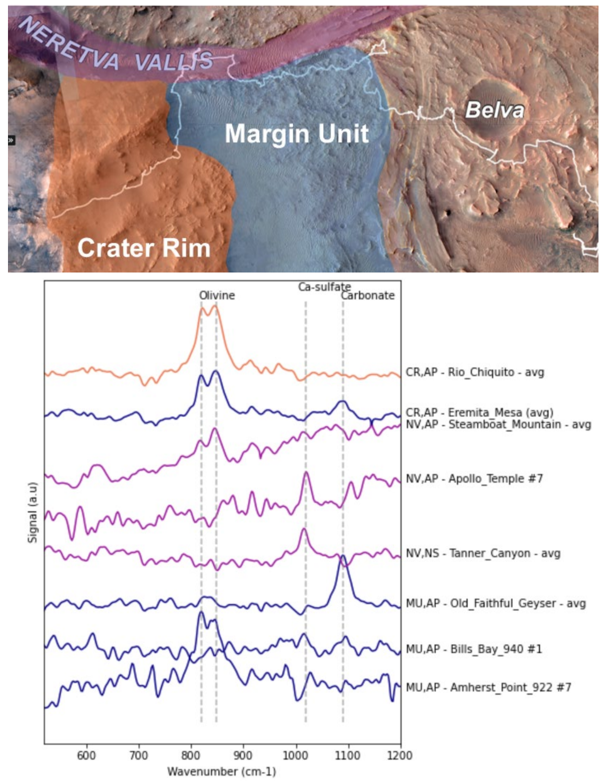

Figure 1 Highlight of the different unit, with the traverse of Perseverance. In matching colors, under the map, we present characteristic Raman spectra of each unit.

Data from these spectra showed, for some of the targets, combinations of olivine with Fe-Mg carbonates at variable intensities, with the main carbonate band ranging in positions between 1088 and 1095 cm^{-1} corresponding to slightly variable magnesium enrichment (Fig. 1, blue spectra). The composition of these carbonates as well as their possible relationship to olivine is described elsewhere [5].

Results in Neretva Vallis (NV): On the way to the CR, Perseverance explored the riverbed of the ancient inlet channel. Within NV, the Bright Angel formation was investigated with particular attention [7] [8]. In the numerous light-toned veins crossing the bedrock, SupeCam detected calcium sulfates, with a majority of anhydrite type II Raman signatures (main feature at

1015 cm^{-1}, e.g. Tanner Canyon in Fig. 1), although one of the targets showed a shift in the position of this band, compatible with a certain degree of hydration (bassanite-anhydrite mixture, Apollo Temple in Fig 1) in this sulfate. For the second time of the mission, sulfate signatures were observed in association with an elevated continuum signal in the Raman spectra [9]: some targets at Bright Angel show the highest background of the entire mission (see Apollo Temple in Fig. 2). The origin of this continuum can be attributed to different sources, including the presence of minor elements or defects in the lattice, small crystal size or, most relevant for the mission, the presence of organics. Complementary analyses by X-ray fluorescence and deep UV Raman on Cheyava Falls revealed evidence of chemical processes and compositions with strong astrobiological potential [10-11]. The origin of this SuperCam strong continuum is currently under study.

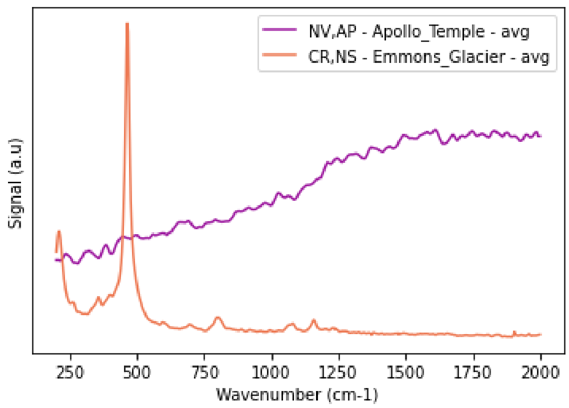

Figure 2 – Elevated continuum signal in the Apollo Temple abraded patch (Bright Angel, NV) and quartz detection on the Emmons Glacier float rock (CR).

Crater Rim: As Perseverance started its climb up the rim of the impact crater, and to sol 1353, SuperCam performed a total of five Raman activities on three abraded patches and one natural surface. At the beginning of the climb, in the target known as Eremita Mesa, Raman spectra showed evidence of olivine and carbonates, with nicely resolved olivine doublets and a weak carbonate mode around 1090 cm^{-1}, very similar to observations in the MU. Later analyses started to show olivine, but no carbonates, which could be an indicator of a lower water activity in this region, discussed elsewhere [12].

Most remarkable was the detection of quartz in the target Emmons Glacier (Fig. 2), a light-toned float rock analyzed on sol 1315, showing an intense quartz spectrum with several secondary features in all points analyzed, compatible with a well crystallized quartz [13]. The main band of quartz minerals can be shifted due to high pressure processes; in the case of Emmons Glacier, SuperCam Raman could thus rule out impact-related processes.

Conclusions: SuperCam's TRR has contributed extensively to the characterization of the carbonate-rich rocks in the MU, the complex aqueous alteration in NV and the diverse mineralogy in the CR (although a lot of this diversity was not sampled with Raman analyses). The ability of Raman spectroscopy to provide insights to the magnesium-iron ratio in the detected carbonates and olivines, in association with LIBS data, gives valuable inputs on describing possible alteration processes in an early and wet Mars [5][9].

The sensitivity of Raman spectroscopy to changes in the crystal lattice due to pressure could play a pivotal role in the ongoing crater rim campaign, by identifying polymorphs associated with high-pressure processes as impacts, or band shifts originated by the pressure strain.

Finally, the luminescence that is also measured along with Raman spectra could provide interesting insights in the possible biogenic origin of the features described in Cheyava Falls, and SuperCam's results are currently part of in-depth studies performed by proximity science instruments.

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