PRINCIPAL COMPONENT ANALYSIS ON THE SUPERCAM-LIBS SPECTRA OF ROCK TARGETS IN THE FIRST 640 SOLS IN JEZERO CRATER.

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Introduction: The Perseverance rover completed, since leaving its Octavia Butler landing site in Jezero crater, the first science campaign on sol 381. That Crater Floor Campaign comprised the analysis of outcrops, rocks and regolith targets of the Máaz and Séítah formations together with the Artuby, and Content members. After completion of the Crater Floor campaign, the rover started the Rapid Traverse campaign (sols 382-414) to the delta front. The Delta Floor campaign started on sol 415 analyzing the Máaz/ Séítah and Séítah /delta contact and the Cape NukShak stratigraphy, to build the geological context for the western delta. Since then, many bedrocks and regolith targets have been examined, ending with the first two regolith samples that were taken on sol 639. During those science campaigns, several rock samples were collected and the abraded surfaces, tailings and cuttings were analyzed.

More than 500 targets were interrogated by SuperCam, a remote-sensing instrument that combines high-resolution imaging, visible and near-infrared (VISIR) reflectance spectroscopy (0.4-0.85, 1.3-2.6 µm), remote time-resolved green-laser Raman and fluorescence spectroscopy, laser-induced breakdown spectroscopy (LIBS), and acoustic sensing [1, 2].

A detailed textural, chemical, and mineralogical analysis of the Máaz formation and the Content member of the Séítah formation concluded that they are igneous (lava flows) [3]. The Máaz formation has some of the lowest Mg# (=molar 100×MgO/MgO+FeO) of all martian igneous rocks analyzed so far, with a mineralogy dominated by Fe-rich augite to possibly ferrosilite as well as plagioclase, and minor phases such as Fe-Ti oxides and Si-rich phases, without any olivine signals at the surface of the targets.

The Séítah formation consists of an olivine cumulate series which is weakly altered and preserves its primary texture and mineralogy. Séítah rocks are dominated by millimeter-size grains of olivine with presence of augite, pigeonite pyroxenes and other primary minerals like plagioclases and Cr-Fe-Ti-oxides [4].

Most of results are based on the derived MOC values (major-element oxide compositions in weight percent) obtained after applying the calibration functions to the LIBS data [5]. The LIBS spectra were collected from 1x5, 1x10 and 3x3 rasters on those bedrocks of Máaz, Séítah and Crater Floor units.

This communication focuses on the principal components analysis (PCA) of the LIBS spectra collected from outcrops and rocks as well as from the abraded surfaces, prior to coring, and from the holes and extracted crushed materials obtained during the drilling process. The aim of this analysis is to determine whether the different analyzed materials can be better differentiated using the whole LIBS spectra, rather than using derived composition values.

Differentiation and grouping using PCA: The LIBS spectra of rock Targets until sol 640 were considered together with those of the onboard calibration targets of the SuperCam (SCCT) instrument [6,7]. The median of the LIBS spectra of each raster from the rock and SCCT targets were used to perform the PCA using the Unscrambler software [8]. Figure 1 shows the plot of the obtained scores using the two first Principal Components (PCs). Different colors are used to visualize the distribution of rocks initially assigned to the different units. The scores of the SCCT targets (black dots) are also included for comparison.

In the PCA scores plot (Figure 1), 85% of the total variance among rocks and SCCT targets is explained with only two components. The position of the SCCT targets in the PC2 vs PC1 plot helps us to visualize the reasons (variability in the LIBS spectra as a function of the elemental composition) for the observed distribution on the four quadrants of the plot.

The right side of PC1 is dominated by the felsic SCCT targets (PMIOR0507, orthoclase, and PMIAN0106, Andesine), while the left side covers the Mg-rich SCCT targets (TSERP0102, Serpentine/Talc, PMIEN0602, enstatite, and PMIFA0506, Mg-rich olivine). The upper side of PC2 is dominated by the Fe-rich SCCT targets (LCMB0006, chert, and PMIFS0505, ferrosilite) while the lower part covers the Ca-rich ones (TAPAG0206, apatite, and LCA530106, calcite).

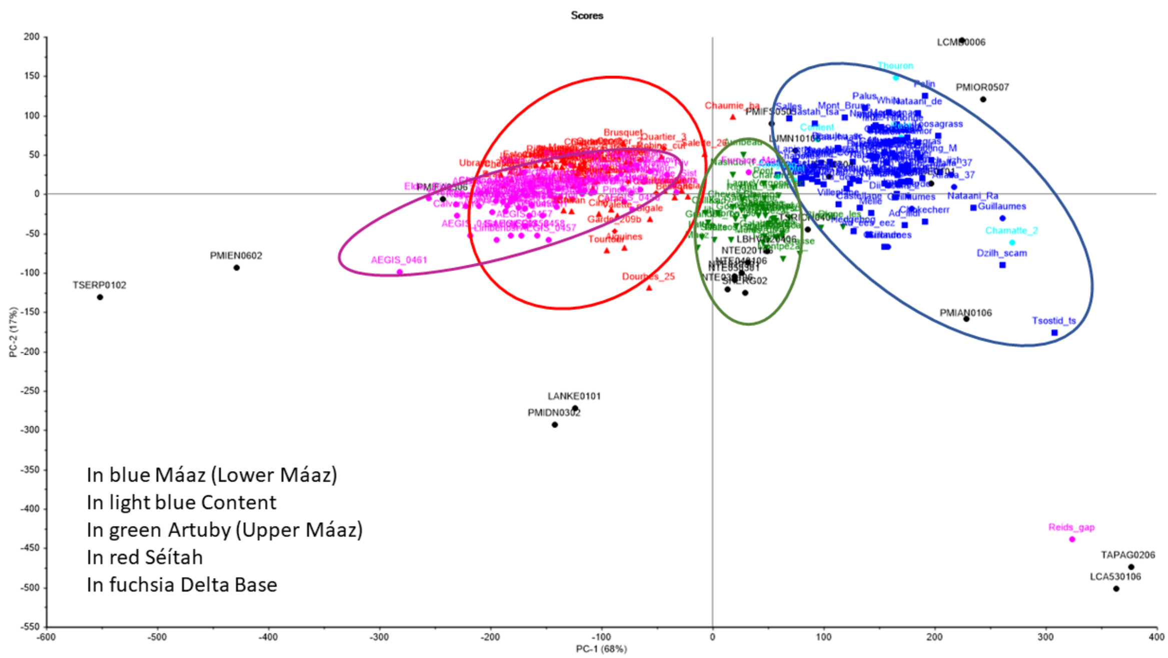

Fig. 1 Scores Plot of the two Principal Components (PC2 vs PC1) obtained in the PCA treatment of the LIBS spectra (median for each raster) of the rocks until sol 640 and SCCT targets. The SCCT targets are represented in black.

Distribution and Interpretation: The Máaz formation (dark blue) and the Content member (light blue) are centered with regard to PC2 but in the right most side for PC1, consistent the most felsic rocks found in the Crater Floor of Jezero [3].

The Artuby ridge, also known as Upper Máaz [3] targets (green), are centered on both PCs and also distributed together with the more basaltic of the SCCT targets (the NTE series, LBHVO20406, standard basalt, and SHERGO2, the shergottite target).

The rocks and abraded patches of Séítah (red) are centered with regard to PC2 but a little to the left in PC1, consistent with olivine and ferrosilite [4].

The rocks and abraded patches of Delta Floor targets (fuschia) are widespread between the most Mg-rich SCCT targets and olivine/ferrosilite ones, showing common distributions with rocks from Séítah.

The use of the LIBS spectra promotes a better distribution of all the analyzed rocks than the distribution based on the MOC values [8], because the full spectra contain considerably more information than the derived composition values (MOC values).

The PC2 vs PC1 plot shows also some targets, initially assigned to a given formation or member of the Crater Floor, fall in the area of others based on their LIBS spectra.

The initially Upper Máaz rocks and abraded targets, Manior, Lance, Estoublon, Villette, Bellegarde191a, Souche, Montdenier 195, 198, and 198 and Chanoles, are distributed in the area depicted for Lower Máaz. On the contrary, the initially Lower Máaz rocks and abraded targets, Maaz, Lhikan, Naadin, Adaa Daa, Jih, Haa ii Aah, Naltsos, Kad, Cheval Blanc, Champs, Charamel, Lagne, Lattes, Nashdoi and Tely, distribute better with the Upper Máaz targets. Also, Aurent, Sagnes, Monts du Cheval Blancs, Jabron309, Callas, Gourdon and Chamia, initially from Séítah are close to Upper Máaz and Melle close to Lower Máaz. Further discussion is needed to understand and explain this issue (e.g. presence of coatings, degradations, etc).

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