MINERALOGICAL DIVERSITY DETECTED BY SUPERCAM IN THE FLUORITE-SULFATE RICH VEIN AT POINT CLOATES TARGET, IN MARGINAL UNIT, JEZERO CRATER, MARS.

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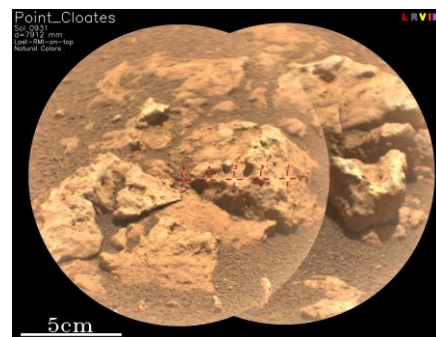
Introduction: The Mars 2020 Perseverance rover conducted the Marginal Unit Campaign between Sols 911-926 and collected the 22nd sample at Pelican Point while at the Hans Amundsen Memorial Workspace. Afterward the rover drove southwest into Turquoise Bay and stopped at a low-relief light-toned fractured unit to perform a number of remote science (RS) activities on Sol 931. Those RS activities included two SuperCam LIBS/VISIR 5x1 rasters on a bedrock target (*Roberts Island*) and on a light-toned rock, with a possible vein (*Point Cloates*).

Figure 2. *RMI observation of Point Cloates showing the points analysed by LIBS. Points 1-4 are in the vein and Point 5 is in a coarse slab below to the rock face.*

Figure 1. *ZCAM image of Point Cloates (Sol 931).*

Point Cloates exhibited a light-toned, vein-like structure that is partially buried by regolith, and is distinct from the rest of the bedrock. To characterize the target, SuperCam observed first with RMI and then executed the 5x1 raster to trace laterally the rock.

Results: Figure 2 shows the RMI product for Point Cloates. Raster locations #1 and #3 fell on the lightest-toned portion of the target, whereas locations #2 and #4 were on darker-toned and partially shadowed areas. Location #5 was within a small pocket of regolith pebbles. The LIBS analyses exhibited major element concentrations that varied substantially among the 5 points (Figure 2), but all had total wt. % values much lower than 100 %, indicating a significant presence of volatiles. In particular, points 1-4 followed a completely different trend compared to nearly all previous observations by SuperCam.
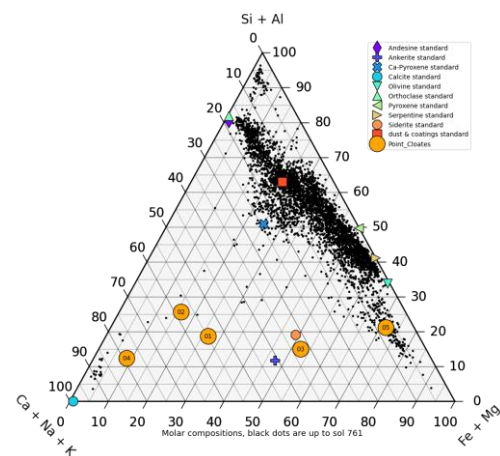

Figure 3. *Distribution of the 5 analysed points (LIBS data) on the ternary plot with the previous observations during the mission shown as small black dots.*

The analysis of the LIBS spectra did not show any detectable chlorine (Cl) or phosphorous (P); thus, chlorides, oxychlorides and phosphates are not at Point

Cloates. Sulphur showed a profile with LIBS spectra quite close to the ones obtained at Reids Gap (a vein analysed in Sol 466 at Hogwallow Flats, containing the anhydrite type II mineral [1]). Hydrogen gave a positive response, thus hydroxyls and/or crystalline water are present. Carbon was not detected above the background from atmospheric CO_2. But the most exciting observation was the clear detection of the molecular CaF emission band, as seen in Figure 4.
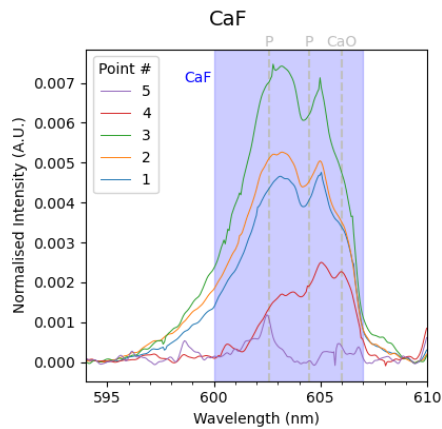

Figure 4. *LIBS spectra in the wavelength range where molecular CaF emission is observed. Points 1-3 shows the clear presence of the CaF typical double band extending across the width of the shaded region.*
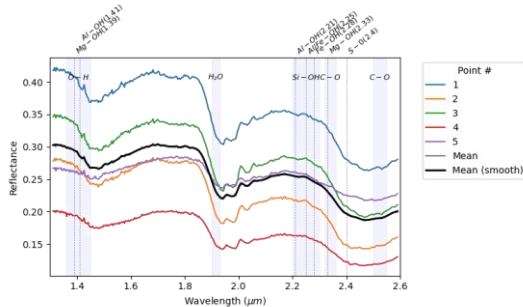

Figure 5. *IR spectra of Points 1-5 showing a rather different behavior for #5.*

The visible spectra showed the presence of Fe(III), and the IR spectra (Figure 5) were modeled quite well using only sulfates and Fe-hydroxides [2]. The large 1.4 μm band and the shallower 1.75 μm is very indicative of gypsum or an intermediate phase between gypsum and anhydrite. There are no IR bands of Al-, Fe- and Mg-hydroxyl, arguing against the presence of phyllosilicates. The presence of minor carbonates might not be excluded from the IR spectra.

Quantification of fluorite content at Point Cloates: Fluorite was quantified using a model developed for ChemCam [3]. The LIBS spectra of Alvord Mountain and Hascosay targets from Gale crater were normalized together with the SuperCam LIBS spectra of Points 1-3. Then three univariate 2nd degree calibration functions were derived at the two maxima (603.16 and 604.97 nm, respectively) and the minimum (604.20 nm) of the double CaF band (see Figure 3). Assuming the calibration from ChemCam is accurate, fluorite cannot be considered a major mineral phase in the vein, but its contribution is important to the mineral diversity of points 1-3 at Point Cloates. The CaF double band has been detected at other rock and regolith targets at Jezero crater since the beginning of the mission, and a general calibration model is in progress [4].

Stoichiometric Modeling for Minerals at Point Cloates: The combined LIBS and VISIR information suggest that chlorides, oxychlorides and phosphates are not in the mineral phases at Point Cloates. Anhydrous and hydrated sulfates must be considered together with fluorite (fluor-apatite cannot be present). The absence of Fe/Mg-OH features in the IR spectra suggest the absence of phyllosilicates. The presence of Fe-hydroxydes (goethite) was considered, and minor amounts of carbonates are possible.

Using the current calibration of fluorine, and assuming the mol/kg values were present as fluorite (CaF_2), points 1-3 showed 5 to 17% wt. % CaF_2. A reliable combination of mineral phases was obtained after the transformation of the initial major-element wt. % oxide values to the scale of mol/kg.

According to models of the IR observations, all Fe and associated Ti was assumed to be as goethite, with mixing coefficients that ranged from 0.01(#1 and 2) to 0.16 (#5). The mixing coefficients for diopside, with different proportions between Ca and Mg, varies from 0.05 (#4) to 0.19 (#5), while those for Na-, Ca-hydrated alumino-silicates ranged from 0.02 (#1 and 3) to 0.09 (#2). The major mineral phases were Ca-sulfates (mixtures of gypsum/basanite/anhydrite), with mixing coefficients that ranged from 0.05 (#5) to 0.42 (#1), and different anhydrous and hydrated forms of Mg-sulfates, which ranged from 0.04 (#4) to 0.58 (#4). The combined mixing coefficients of fluorite+sulfates were in the 0.19-0.82 range, with #1-3 as the most altered points.

References: [1] López-Reyes, G. et al., (2023), *54th LPSC*, #1721. [2] Royer, C. et al., (2024) *55th LPSC* (this conference) [3] Forni, O. et al., (2015) *Geophys. Res. Lett., 42,* 1020-1028. [4] Wolf, Z. U. et al., (2024) *55th LPSC* (this conference).