Jezero Delta mineralogical diversity revealed by SuperCam infrared spectral modeling.

C. Royer[1,*], F. Poulet[2], R. C. Wiens[1], L. Mandon[3], T. Fouchet[4], E. Clavé[5], F. Montmessin[6], O. Forni[7], J. R. Johnson[8], O. Gasnault[7], C. Quantin-Nataf[9], E. Dehouck[9], P. Beck[10], S. Le Mouélic[11], G. Caravaca[7], P. Pinet[7], O. Beyssac[12], C. Pilorget[6], A. M. Ollila[13], A. Brown[14], S. Maurice[7] and the SuperCam team, [1]EAPS, Purdue Univ., West Lafayette, IN, USA; [2]IAS, Orsay, France; [3]Caltech, Pasadena, CA, USA; [4]LESIA, Meudon, France; [5]CELIA, Bordeaux, France; [6]LATMOS, Guyancourt, France; [7]IRAP, Toulouse, France; [8]JHUAPL, Laurel, MD, USA; [9]Univ. de Lyon, Lyon, France; [10]IPAG, Grenoble, France; [11]LPG, Nantes, France; [12]IMPMC/MNHN, Paris, France; [13]LANL, Los Alamos, NM, USA; [14]Plancius Research, Severna Park, MD, USA; *royer10@purdue.edu

Introduction: Since the end of April 2022, the Perseverance rover has embarked on the Delta Campaign with the objective to explore the sedimentary delta of Jezero Crater and characterize its stratigraphy and mineral composition. Among the instruments aboard the Rover, SuperCam [1, 2] plays a key role in this study thanks to its remote measurement capabilities (spectroscopy and imaging), in particular the near-infrared reflectance spectroscopy performed by the IRS instrument [3]. This instrument analyzes light reflected from rocks and soils in the 1.3 – 2.6 µm spectral range and in a field of view of 1.15 mrad, corresponding to an area of about 3.5 mm at 3 m distance. The IRS is thus sensitive to the spectral signatures of primary and aqueous alteration minerals, enabling the analysis of the compositional diversity of rocks and thus to the study of their formation conditions. Here we summarize a modeling approach of the IRS data to examine diagnostic absorption features.

Method: This approach involves several successive steps, using calibrated IRS data [4, 5] of every targets (rocks, soils, abraded patches and drill cuttings):

1. From a spectral criterion based on a combination of band depth and band SNR (*i. e.* a comparison between the band-depth and the instrument precision/noise), the absorption bands are automatically detected and selected from the available data set. This allows us to isolate the strongest signatures and better constrain rock composition. The signatures thus sought are 1.4 µm (H_2O), 1.9 µm (H_2O and OH), 2.2 µm (Al-OH, Si-OH), 2.3 µm (Fe-OH, Mg-OH, CO_3) and 2.5 µm (CO_3).

2. The absorption bands of interest of the selected targets are then modeled by a sum of Gaussians (up to 4) and from this modeling the accurate position of the absorption band minimum (interpolated by the sum of Gaussians) and the band area (calculated using the Simpson's method) are retrieved (Fig. 1).

3. The statistical study of the band position then shows the correlations that can be made between the different absorption bands. The study of the relative surface of the absorption bands, on the other hand, allows us to identify clusters and trends by comparison with laboratory spectra. Working with relative band areas allows us to get rid of spectral effects related to continuum, illumination geometry and grain size.

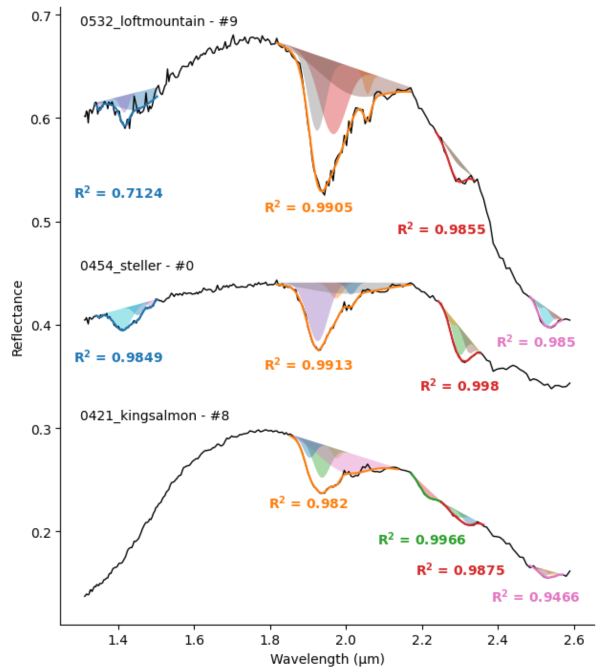

Figure 1: Multigaussian modeling examples.

Results: All measurements in the Delta Front represent a total of about 1,000 spectra spread over 6 geologic and regional units: Devils Tanyard, Hughes River Gap, Hogwallow Flats, lower and upper Rocky Top, and Enchanted Lake.

The histograms of absorption band minimum distribution reveal the diversity of these units (Fig. 2). First, the hydration appears relatively homogeneous, with a similar presence of bands at 1.4 and 1.9 µm. However, the other absorption bands show significant differences. The band at 2.2 µm appears bimodal in many units with two main components: one at 2.20 µm or below attributable to the Al-OH bond in clays, particularly present in Hogwallow Flats, and the other at 2.22-2.23 µm, attributable to Si-OH (hydrated silica) whose presence is more pronounced in

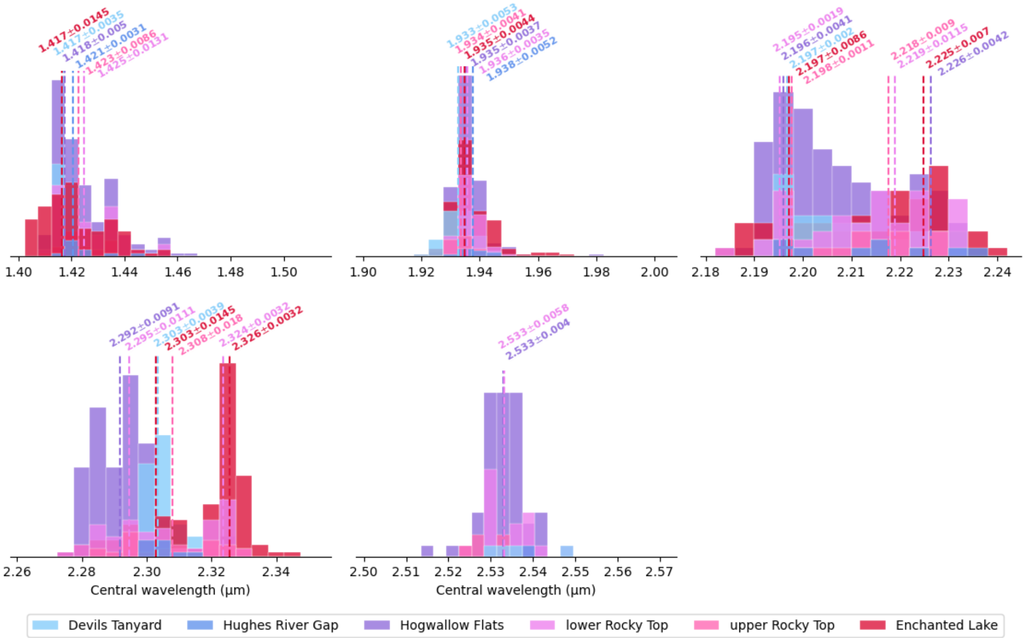

Figure 2: Band minimum histograms for each studied absorption band.

Enchanted Lake.

The band at 2.3 µm appears even more contrasted with a strong dichotomy between Enchanted Lake and lower Rocky Top (peak at 2.33 µm similar to serpentines and Fe-carbonates) and the other units (peak at 2.30 µm attributable to Fe/Mg clays and/or Mg-carbonates)

Finally, the 2.5 µm band is predominantly detected in Hogwallow Flats and Rocky Top, and centered at 2.53 µm, which can be attributed to Fe/Mg-carbonates.

Although not shown here, the analysis of the relative area of absorption bands projected in ternary diagrams (1.4-1.9-2.3 for clays, 1.4-1.9-2.2 for aluminous phases and hydrated silica, and 1.9-2.3-2.5 for carbonate phases) shows that the observations from the different delta units fall into relatively distinct clusters, but all are close to an Fe/Mg-smectite enriched composition with a trend towards serpentines for Enchanted Lake. However, the band at 1.9 µm is proportionally more intense than the others, suggesting the presence of an additional hydrated phase, compatible with Mg-sulfates or hydrated iron oxyhydroxides (ferrihydrite for example).

Conclusion: The study of IR spectra of the delta rocks, supported by their modeling and statistical analysis, reveals the important diversity of their composition. These analyses indicate the presence of numerous aqueous alteration minerals such as Fe/Mg-smectites, alumino-phyllosilicates, serpentines and Fe/Mg-carbonates assembled in complex mixtures which provides compiling evidence of various physical, chemical and energitic conditions during and after the deposition of the deltaic sediments. This method can be used to better constrain the modeling of these spectra in order to retrieve the mineral species present and their abundances, and thus, understand the alteration process that shaped the delta in support of the other investigations [6, 7, 8].

References

[1] Wiens, R. C. et al. (2021) *Space Sci Rev*, 217(1):4.

[2] Maurice, S. et al. (2021) *Space Sci Rev*, 217(3):47.

[3] Fouchet, T. et al. (2022) *Icarus*, 373:114773.

[4] Royer, C. et al. (2023) *Journal of Geophysical Research: Planets*, 128(1):e2022JE007481.

[5] Mandon, L. et al. (2023) *JGR-Planets (in press)*.

[6] Dehouck, E. et al. (2023) *this meeting*.

[7] Mandon, L. et al. (2023) *this meeting*.

[8] Beyssac, O. et al. (2023) *this meeting*.