

**FERRIC SULFATES AT THE JEZERO CRATER DELTA FRONT AS EVIDENCED BY SUPERCAM 433 NM ABSORPTIONS.** J.R. Johnson<sup>1</sup>, R. C. Wiens<sup>2</sup>, E. Cloutis<sup>3</sup>, L. Mandon<sup>4</sup>, S. Maurice<sup>5</sup>, C. Legett<sup>6</sup>, (jeffrey.r.johnson@jhuapl.edu), <sup>1</sup>Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA, <sup>2</sup>Purdue University, <sup>3</sup>University of Winnipeg, Canada, <sup>4</sup>Caltech, <sup>5</sup>IRAP, Toulouse, France, <sup>6</sup>LANL, Los Alamos.

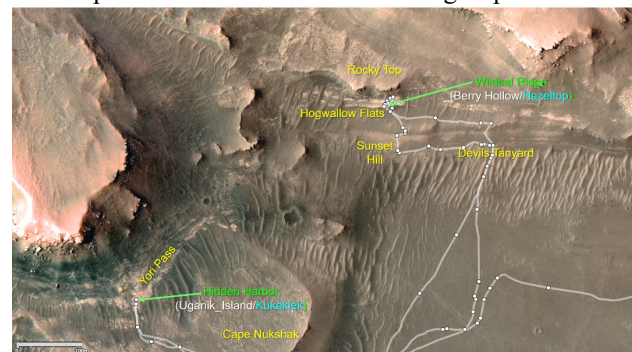
**Introduction:** Recent visible wavelength spectra (379-853 nm) acquired by SuperCam onboard the Mars 2020 *Perseverance* rover revealed the presence of ~433 nm spectral absorptions associated with rocks within discontinuous light-toned units at the delta front of Jezero Crater. This is attributable to the presence of Fe<sup>3+</sup> in ferric sulfates (similar to rare detections from ChemCam passive spectra collected by the Mars Science Laboratory [1]), and corroborated by measurements from other Mars 2020 instruments [2,3].

**SuperCam VISIR Data.** SuperCam acquires high spectral resolution VIS (379-853 nm) and IR (1300-2600 nm) spectra as rasters covering targets at multiple locations with fields of view of 0.74 and 1.15 mrad, respectively [4]. VIS spectrometers sample the blue-violet (VIO, 379–464 nm) and green-to-infrared (VNIR, 535–853 nm) ranges. The VNIR transmission spectrometer uses three regions: Green (535-620 nm), Orange (620-712 nm), and Red (712-853 nm). Here we use VIS data, converted to radiance via an instrument transfer function derived from lab measurements [4,5]. Relative reflectance spectra were generated using a radiance spectrum acquired of the onboard AluWhite calibration target [5], and then corrected for solar incidence angle. Decreased sensitivity near detector boundaries for Green/Orange (~620 nm) and Orange/Red (~719 nm) results in minor artifacts, particularly for bright targets. VIO data were smoothed using a 50-channel median filter to compensate for their relatively low signal-to-noise.

**Data Collection and Results.** SuperCam spectra with the most pronounced ~433 nm absorptions occurred at Wildcat Ridge (WR) in the light-toned Hogwallow Flats (HF) region and at Hidden Harbor (HH) near the similarly light-toned Yuri Pass (YP) region (**Fig. 1**). At WR, SuperCam obtained two observations of the Berry Hollow (BH) abrasion target and one of the Hazeltop (HT) sample tailings (**Fig. 2**). At HH, one observation of the Uganik Island (UI) abrasion and one of the Kukaklek (KK) sample tailings were acquired (**Fig. 3**). At WR, rock fragments crushed by the rover wheels at the Lands Run (LR) target also exhibited bright surfaces with ~433 nm bands (Fig. 2d, 2e). VIS spectra from these targets (**Fig. 4**) demonstrated similar positions of the ~433 nm band. However, the BH, HT, and LR spectra were redder, exhibited stronger ferric (545 nm) band depths and steeper drop-offs > 765 nm compared to the flatter spectra of the UI and KK targets. The lower relative

reflectance and spectral contrast of the KK tailings may also result from minor shadowing of individual grains (Fig 3b, 3d), or contributions of minor opaque minerals.

**Comparison to Lab Spectra.** Ferric sulfates exhibit absorption bands near 433 nm, sometimes with weaker ~530 and/or ~870 nm bands. The ~433 nm band is related to the (<sup>6</sup>A<sub>1g</sub> → <sup>4</sup>A<sub>1g</sub>, <sup>4</sup>E<sub>g</sub>) ferric iron spin-forbidden crystal field transition, where the shape and position of this band are related to the distortion of the iron octahedra [1,6,7]. Laboratory spectra of a selection of candidate ferric sulfates (**Fig. 5**) exhibit similar narrow absorption bands near 433 nm and downturns at wavelengths <410 nm. However, most also show pronounced downturns in reflectance longward of ~650-725 nm, which are shorter than the ~765 nm peak reflectance positions observed in the BH/HT/LR targets. For comparison, the sideronatrite lab sample exhibits a flatter spectrum more like the UI/KK target spectra.

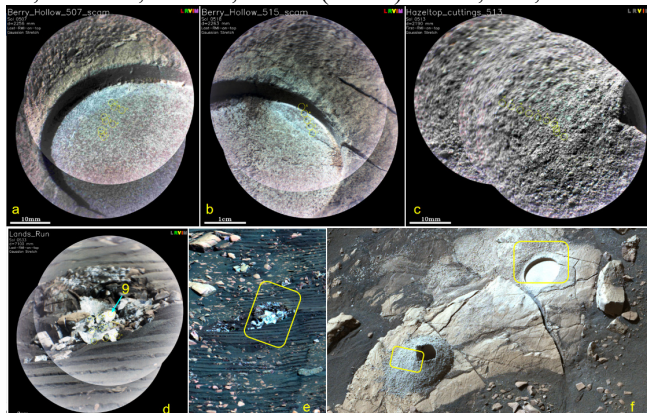


**Figure 1.** HiRISE basemap showing *Perseverance* rover traverse (line gray lines) and stops (white dots), labeled with features of interest (white text = abrasion targets; cyan = core tailings). Scale bar is 100 m.

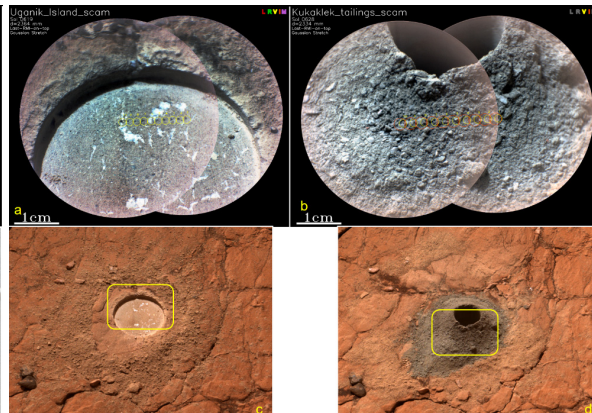
**Discussion.** The similarity in VIS spectra between the HF and YP light-toned units is consistent with similarities of spectra observed by SuperCam IR and Mastcam-Z spectra [8-9]. The fine-scale chemical heterogeneities observed in the abrasion targets reflect the mixed nature of these materials, of which sulfates with variable iron content were a contributor [2,3]. Nonetheless, the unique detections of ~433 nm bands in the HF and YP units are consistent with the hypothesis that they generally experienced similar formation and/or alteration histories [cf. 11]. However, differences in grain size and ferric content between BH and UI, and the unique presence of mm-scale sulfate veinlets in UI [2,3] suggest that the formation, aqueous alteration, and/or oxidation of rocks exposed along the Jezero delta front was locally variable.

**References:** [1] Johnson, J., *Amer. Mineralogist*, 101, 1501–1514, 2016; [2] Hurowitz, J., *this conf.*; [3] Roppel, R., *this conf.*; [4] Wiens, R., *Space Sci. Rev.*, 217, 4 (2021); Maurice, S., *Space Sci. Rev.*, 217(3), 1–108 Manrique, J., (2020) *Space Sci. Rev.* 217, 1–40, 2021; 40, 2021; [5] Legett, C., LPSC, #1516, 2021; #2553, 2022; [6] Rossman, G.R. (1975) *Amer. Mineral.* 60, 698–704; Cloutis, E.A. (2006a) *Icarus*, 184, 121–

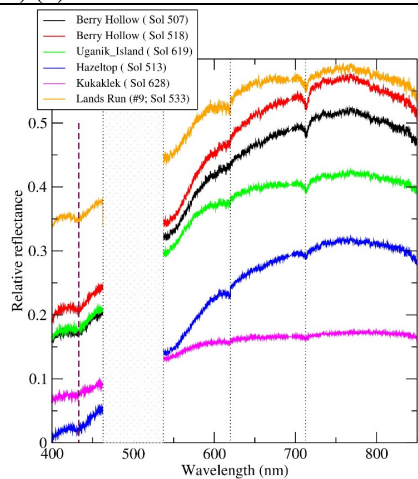
157; Cloutis, E.A. (2008) *Icarus*, 195, 140–169; Skulte, E.C. (2015), *JGR*, 120, 2014JE004784; [7] McCollom, T. M. (2014), *Amer. Min.* 99, 5–6, 948–964; [8] Mandon, L. et al., *this conf.*; Dehouck et al., *this conf.*; [9] Núñez, J., et al., *this conf.*; [10] [www.uwinnipeg.ca/c-tape/sample-database.html](http://www.uwinnipeg.ca/c-tape/sample-database.html); [11] Kalucha et al., *this conf.*; Broz et al., *this conf.*



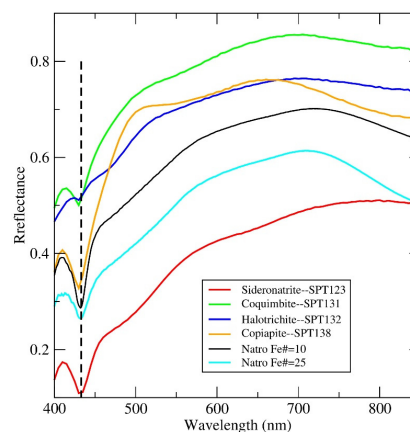
**Figure 2.** SuperCam enhanced color RMI images of Berry Hollow abrasion (5 cm diameter) acquired on Sols 507 (sequence ID scam04507) (a) and 518 (scam01518) (b), along with tailings generated from coring target Hazeltop on Sol 513 (scam01513) (c), and broken rock fragments at Lands Run (Sol 533, scam04533) with raster location #9 labeled (d). Also shown for context are portions of Sol 533 (zcam03427) enhanced color Mastcam-Z image of Lands Run (e) and Sol 513 enhanced color Mastcam-Z mosaic (zcam08538) (d). Yellow boxes are locations of RMIs.



**Figure 3.** SuperCam enhanced color RMI images of Uganik\_Island (UI) abrasion (5 cm diameter) acquired on Sol 619 (scam01619) (a) and tailings generated from sampling target Kukaklek on Sol 628 (scam01628) (b). Also shown for context are Mastcam-Z natural color images of UI (Sol 619; zcam03487) and Kukaklek (Sol 628; zcam03492) (d). Yellow boxes are locations of RMI images.



**Figure 4.** SuperCam VIS spectra of abrasion patches, core tailings, and broken rocks that exhibit ~433 nm bands (dashed line). Spectra represent raster averages unless raster location number is noted. Regions <465 nm have been smoothed using a 50-channel median filter. Dotted lines represent regions where detectors join; dotted box is empty region between VIO and VNIR detectors.



**Figure 5.** Laboratory spectra of candidate ferric sulfates exhibiting ~433 nm bands (dashed line): Sideronatrinite  $[Na_2Fe^{3+}(SO_4)_2(OH) \cdot 3(H_2O)]$ , Coquimbite  $[Fe_2^{3+}(SO_4)_3 \cdot 9(H_2O)]$ , Halotrichite  $[Fe^{+2}Al_2(SO_4)_4 \cdot 22H_2O]$ , Copiapite  $[(Fe_{2/3}^{3+}Fe_{4/3}^{3+}(SO_4)_6 (OH)_2) \cdot 20(H_2O)]$  from [10], along with two spectra from the Jarosite  $[KFe_3(SO_4)_2(OH)_6]$ -Alunite  $[KAl_3(SO_4)_2(OH)_6]$  solid solution from [7] with differing Fe# (defined as  $(100 \times Fe / (Al + Fe))$ ).