SPECTRAL DIVERSITY IN FLUVIO-DELTAIC DEPOSITS IN THE WESTERN DELTA FAN IN JEZERO CRATER, MARS AS SEEN WITH MASTCAM-Z ON THE MARS 2020 *PERSEVERANCE* ROVER.

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Introduction: NASA's Mars 2020 *Perseverance* rover landed on the floor of Jezero crater, Mars on February 18, 2021. Jezero crater is a 45 km diameter Noachian-aged basin characterized by deposits of an ancient lake-delta system during the Late Noachian-Early Hesperian epochs on Mars [1-2]. The deposits of the western delta fan record an early habitable environment on Mars that may preserve potential biosignatures, making it a high-priority target for investigation by *Perseverance* and collection of samples for future return to Earth.

After landing, *Perseverance* investigated and collected samples from the Máaz and Séítah formations on the crater floor [3] through March 2022. *Perseverance* arrived at the delta front in April 2022 and investigated the sedimentary deposits of delta lobes at the "Cape Nukshak" (CN) and "Hawksbill Gap" (HBG) locations [4]. *Perseverance* subsequently explored the deposits of the curvilinear and blocky units in the upper fan from February 2023 to September 2023 [5]. Here we use Mastcam-Z [6] images and multispectral observations over a range of scales, from close-up observations of abraded patches, to outcrop and landscape observations to characterize the stratigraphy, spectral diversity and mineralogy of the rocks and facies within the "delta front" and "upper fan" campaigns.

Mastcam-Z Instrument: Mastcam-Z is a multispectral, stereoscopic, dual imaging system composed of two zoom cameras mounted on the Remote Sensing Mast of the rover [6]. Its two "eyes" generate high-resolution color wide-angled and zoomed-in images (focal lengths ranging from 26 mm to 110 mm) of close and distant targets. Each camera has a FOV from ~5° to ~23° along longest axis (IFOV from 67 to 283 µrad/pix) and 3 broadband RGB and 6 narrowband filters, spanning the Visible and Near-Infrared wavelengths (442-1022nm). Mastcam-Z observations are calibrated to I/F and spectra are converted to reflectance factor (*R**) [7-8]. Spectral parameters are used to detect areas with contributions from olivine, pyroxene, and oxide minerals [9].

Spectral Diversity Along Delta Fan: Mastcam-Z multispectral observations of the delta front reveal mineral diversity among the different facies (Fig. 1).

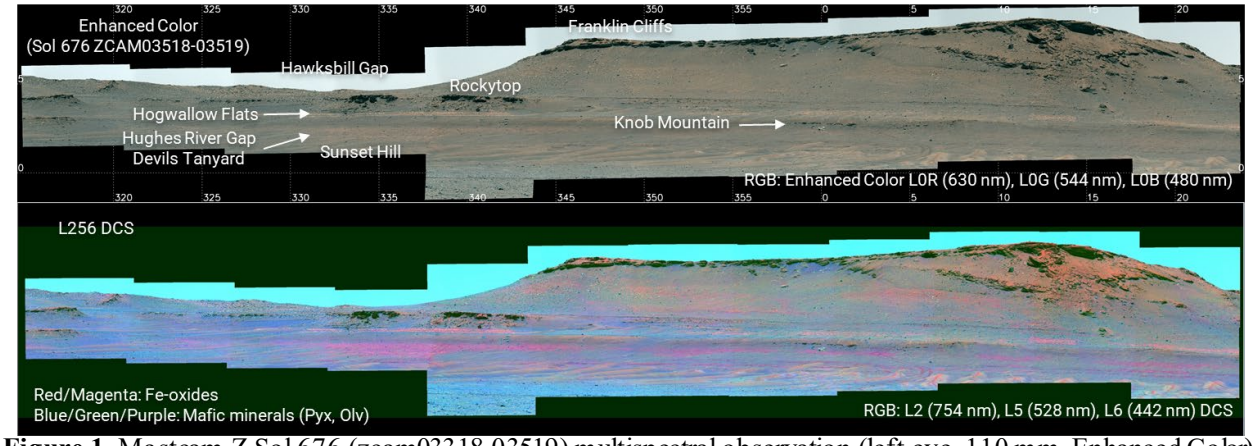

Figure 1. Mastcam-Z Sol 676 (zcam03318-03519) multispectral observation (left eye, 110 mm, Enhanced Color) showing the different facies in the delta front at Hawksbill Gap (**Top**). (**Bottom**) Decorrelation stretch (DCS) of Mastcam-Z bands L2, L5, and L6 highlight differences in composition along the delta front. Magenta/pink/beige colors are associated with ferric iron minerals, while blue/brown/cyan colors are associated with ferrous iron minerals. These spectral differences correspond well with different stratigraphic members in the delta front at Hawksbill Gap, including Devils Tanyard, Hughes River Gap, Knob Mountain, Hogwallow Flats, Lower Rockytop, and Upper Rockytop. Delta scarp is approximately 40 m tall from the base of Sunset Hill to the top of Franklin Cliffs.

Cape Nukshak Observations: At the base of Cape Nukshak (CN), thinly-laminated sandstones and mudstones of the "Kaguyak" and "Amalik" members [4] have a similar bulk composition, but Kaguyak is more oxidized due to the presence of hematite (Fig. 2D). Upsection, light-toned recessively weathered siltstones of "Knife Creek" [4] have strong absorptions consistent with crystalline hematite. Capping CN, are dark-toned, coarse-grained layered sandstones of "Alagnak" [4,11], that have absorptions of olivine and Low-Ca Pyroxene (LCP). At "Yori Pass", light-toned siltstones [4] have spectral features consistent with hematite and possible ferric sulfates (Fig. 2E).

Hawksbill Gap Observations: At the base of Hawksbill Gap (Figs. 1 & 2A-C), finely-layered recessive sandstones of the "Devils Tanyard" (DT) and "Hughes River Gap" (HRG) members [4] also show strong absorptions consistent with hematite, while spectra of some grey coatings suggest the presence of other oxides, such as Mn-oxides [10] (Fig. 2A). Overlying the DT and HRG members are the dark-toned "Knob Mountain" (KM) and "Boston Knob" (BK) members [4], which spectra are dominated by olivine and LCP. In the "Hogwallow Flats" (HWF) member, light-toned, finely-layered mudstones [4] have similar spectral features to Yori Pass member consistent with hematite and possible ferric sulfates (Fig. 2C). Overlying Hogwallow Flats are more resistant layered coarse sandstones to conglomerates of the lower and upper "Rocky Top" (LRT & URT) members [4] with spectral features consistent with the presence of ferric iron, carbonate, LCP, and hydrated minerals (Fig. 2B).

Upper Fan Observations: In the upper fan [5], bedded coarse-grained sandstones of the Tenby formation within the curvilinear unit (Fig. 2F & 2G) have spectra consistent with olivine and/or Fe-bearing carbonate. Upsection, pebbly sandstones to conglomerates of the Otis Peak formation show diverse mineral assemblages with olivine and pyroxene grains, possible Fe-carbonate grains/cements, and Al-rich or Si-rich clasts, which appear yellow in Mastcam-Z R6, R3, and R1 Decorrelation Stretch (DCS) images (Fig. 2H-2J). Rocks in the upper fan (Fig. 2F-2J) appear to be less oxidized, with less Fe-oxide present, than in rocks in the delta front (Fig. 2A-E), although the image-dependent nature of DCS algorithm and products makes comparisons among scenes qualitative.

Summary: The spectral diversity observed in the sedimentary rocks in the delta front and upper fan preserve a record of variable aqueous conditions, especially variability in redox conditions, during deposition and post-depositional alteration by diagenetic fluids. These observations help constrain an early aqueous environment on Mars that may have been favorable for the preservation of potential biosignatures.

References: [1] Stack et al. (2020), *SSR* 216, 127. [2] Mangold et al. (2021), Science, 374, 711. [3] Farley et al. (2022), Science, 377, 6614. [4] Stack et al. (2023), JGR, In Review. [5] Nachon et al. (2023), this volume. [6] Bell *et al. (2020)*, SSR, 217:24. [7] Hayes *et al. (2021)*, SSR, 217:29. [8] Kinch *et al. (2020)*, SSR, 216:141. [9] Rice et al. (2023) JGR, In Press. [10] Garczynski et al. (2023), JGR, In Review. [11] Million et al. (2023), LPSC.

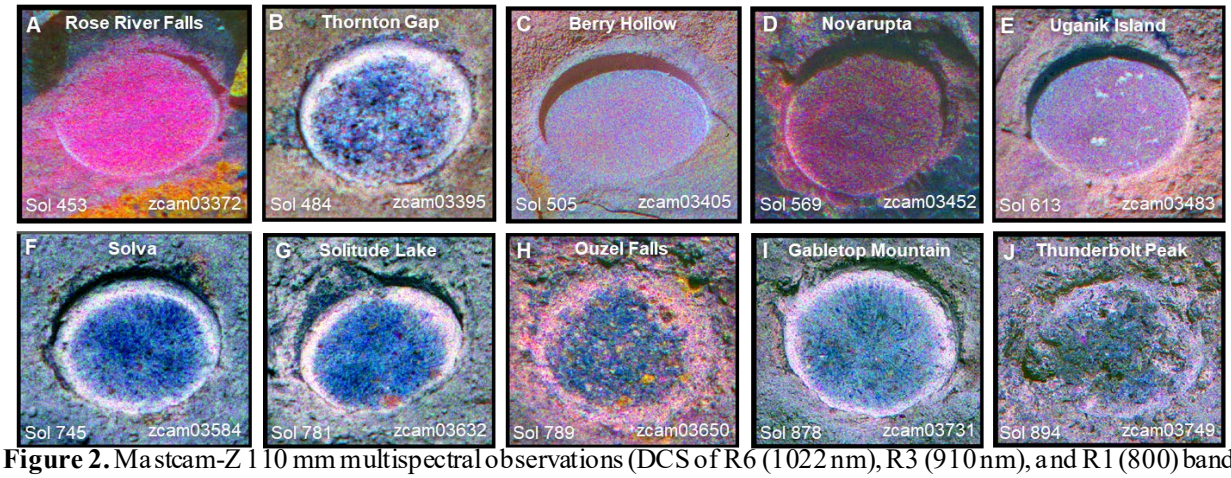

Figure 2. Mastcam-Z 110 mm multispectral observations (DCS of R6 (1022 nm), R3 (910 nm), and R1 (800) bands) of abrasion patches of different facies in the Shenandoah formation in the delta front, including Devils Tanyard (DT), Hogwallow Flats (HWF), Lower Rockytop (LRT), Amalik (Am), and Yori Pass (YP) members (**A-E**), and upper fan, including Tenby formation and Otis Peak formation (**F-J**). Decorrelation stretch (DCS) of Mastcam-Z bands R6, R3, and R1 highlight differences in composition, with magenta/pink colors associated with ferric iron minerals such as hematite, blue color associated with olivine or Fe-carbonate, purple with pyroxene, and yellow with possible Al-rich/Si-rich minerals. Note that DCS images are scene-dependent, so comparisons are qualitative. Graphics generated using [11]. Abrasion patches are 5 cm in diameter.