BIOSIGNATURE PRESERVATION POTENTIAL OF SULFATE-RICH ROCKS FROM HOGWALLOW FLATS, JEZERO CRATER, MARS.

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Introduction: The *Perseverance* rover on the Mars 2020 mission discovered fine grained sedimentary rocks in the Hogwallow Flats member of the Shenandoah Formation in the ~3.6- to 3.8-billion-year-old Jezero crater, Mars. Mudstones and sandstones at the 3-meter-thick Hogwallow Flats (HWF) outcrop, and a laterally equivalent outcrop known as "Yori Pass", show extensive evidence of diagenesis (alteration after deposition). Enhanced preservation of organic matter and other biosignatures can occur in early diagenetic environments associated with aqueous alteration in a lake, floodplain or pro-deltaic setting, as envisaged for the HWF member [1]. Three drilled rock cores were collected from the HWF member, which may be returned to Earth via Mars Sample Return. They are considered to be the samples with the highest potential to preserve organic compounds and biosignatures out of all samples collected so far by *Perseverance* (as of mission Sol ~1000) [2]. This work outlines the implications of diagenesis for biosignature preservation in the HWF samples.

Methods: Mastcam-Z is a multispectral stereo imaging system onboard *Perseverance*. The instrument is a pair of zoomable multispectral cameras that allow for constraining the mineralogy of silicates, oxides, oxyhydroxides, and hydrated minerals [3]. SuperCam is comprised of a laser-induced breakdown spectrometer (LIBS), Raman spectrometer (532 nm), a time-resolved fluorescence spectrometer, and a visible and short-wave infrared (VISIR) spectrometer, as well as a microphone and remote micro-imager [4]. We use remote sensing observations from Mastcam-Z and SuperCam to correlate chemical and multispectral properties with textures and morphology of altered rocks at HWF.

Results: A sequence of light-toned, sulfate cemented bedrock overlying dark-toned, mottled and recessive bedrock repeats at least twice at HWF and possibly several additional times at Yori Pass. Diagenetic features and textures at HWF include light-toned bedrock grading downward into red-green-gray mottled bedrock [5], elevated chemical index of alteration [6] authigenic Fe/Mg sulfates, Fe/Mg clay minerals and Fe oxides [7], putative concretions, Ca sulfate-filled fractures, and rock coatings. Abrasion patches (Fig. 1) revealed multiple generations of sulfates including intergranular cements and detrital sulfate grains [8]. Heterogeneity in Hogwallow Flats likely represents different stages of diagenesis that occurred under habitable conditions in the presence of liquid water and variable redox conditions [9]. Most notably, we observe major differences in redox state between Yori Pass and HWF. Mastcam-Z observations indicate low Fe^{3+} content of Yori Pass

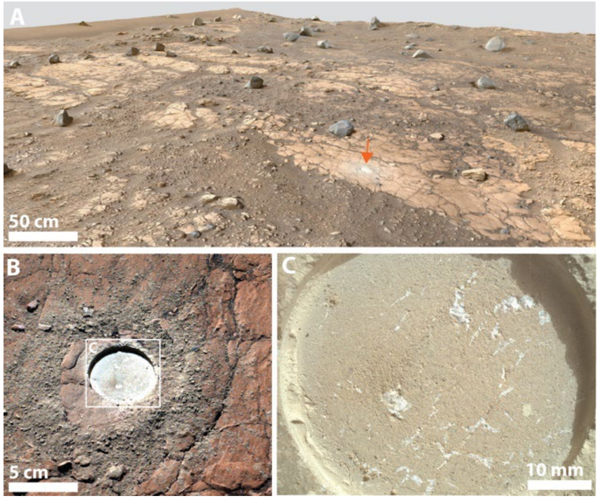

Figure 1. *Outcrop at Yori Pass and light-toned sulfate-bearing material in bedrock abrasion patch. A) 3D model of Mastcam-Z enhanced color images at Hidden Harbor outcrop, Yori Pass, where orange arrow indicates Uganik Island abrasion patch (zcam08621, Sol 614); B) Mastcam-Z enhanced color image of Uganik Island abrasion patch showing abraded surface (Sol 614, zcam 03487); C) WATSON image (Sol 612, SRLC00746) showing distribution of light-toned sulfate-bearing material in patchy white areas.*

abrasions and drill tailings when compared to HWF (Fig. 2), indicating the Yori Pass core sample may be less oxidized (Fig. 3).

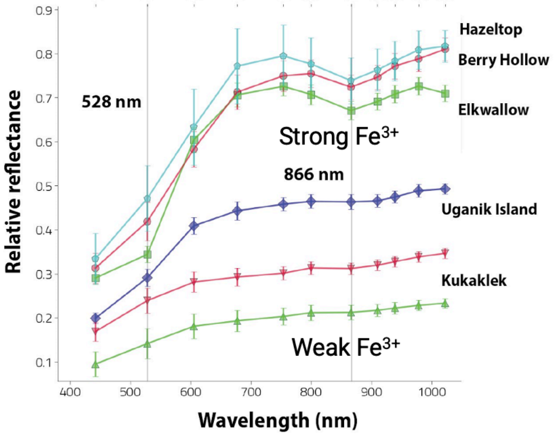

Figure 2. *Mastcam-Z multispectral observations of abrasion patches and drill tailings showing variable redox state (Fe^{3+} content) at Hogwallow Flats (top 3 traces), and Yori Pass (bottom 3 traces); Co-occurring 528 nm and 866 nm bands at HWF suggest finely crystalline red hematite*

Discussion: *Depositional setting*. Successive sedimentation and alteration events led to the formation of a sequence of fine-grained and horizontally-laminated strata comprising several meters of stratigraphy. We interpret this interval of the Shenandoah Formation as either A) a subaerial floodplain that experienced episodes of leaching and/ or groundwater alteration and evaporation, or B) a shallow subaqueous (lacustrine or pro-deltaic) environment subject to aqueous alteration under variable redox conditions [1]. An aeolian origin for HWF has also been proposed [5]. Sedimentary textures and structures that could distinguish between these possibilities were not apparent [1] due to the poorly outcropping nature of HWF strata and diagenetic obliteration of primary sedimentary structures.

Diagenetic environment. The repeating sequence of light-toned, sulfate cemented bedrock overlying dark-toned, mottled and recessive bedrock is consistent with multiple episodes of sedimentation and alteration in shallow subaqueous to subaerial settings. Based on terrestrial examples [10], mottling features in HWF mudstones likely formed as a result of a fluctuating water table during early diagenesis, possibly at a lake margin or overbank setting (e.g., variations between saturated and unsaturated conditions). Sulfate-rich outcrop surfaces with ~20 wt. % Fe/ Mg sulfates [11] likely represent periods of evaporation during early diagenesis.

Implications for biosignature preservation. Nodules/concretions, phyllosilicates, sulfate grains/ cements, and mottling features may be sites of enhanced organic matter preservation. Cores may partially include mottled mudstones stratigraphically below sulfate-cemented outcrop surfaces [7]. Sulfates (both authigenic and detrital) may contain fluid inclusions that in terrestrial examples preserve pristine microbial cells and other biosignatures [8]. A major finding of this work is differences in redox state between HWF and Yori Pass (Fig. 2), which indicate putative redox gradients that could have provided an energy source for microbial metabolism [9]. Thus, the rock cores collected (Fig. 3) could preserve morphological, textural, chemical and/or isotopic biosignatures if life was ever present in ancient Jezero environments. These samples therefore provide an ongoing incentive for Mars Sample Return.

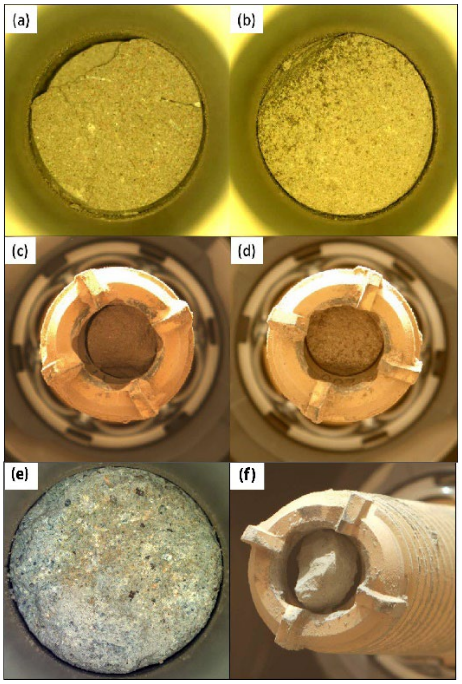

Figure 3. Rock cores collected by Perseverance from Hogwallow Flats (A-D) and Yori Pass (E-F). *A-B) Cachecam images of Hazeltop core (HWF, Core #12) and Bearwallow core (HWF, Core #13); C-D), Mastcam-Z images of Hazeltop and Bearwallow cores in coring bit; E-F) Cachecam and Mastcam-Z images of Kukaklek core (Yori Pass, Core #14). Sample tube diameter is ~1 cm.*

References: [1] Stack et al. (2023) *LPSC 53* [2] Bosak, Shuster et al. (2024) *JGR: Planets (In review)* [3] Bell et al. (2021) *SSR. 217* [4] Wiens et. al. (2021). *SSR 217*. [5] Benison et al. (2022) *LPSC 53*. [6] Dehouck et al. (2023) *LPSC 53* [7] Broz et al. (2023) *LPSC 53* [8] Benison et al. (2024). JGR: Planets *(in review* [9] Mandon et al. (2024) *JGR:Planets (in review)* [10] Kraus et al. (2002) *SEPM 72:4* [11] Hurowitz et al. (2023) *LPSC 53*