

PIXL ANALYSES OF SEDIMENTARY ROCKS IN THE MARS 2020 PERSEVERANCE UPPER FAN CAMPAIGN IN JEZERO CRATER. K.L. Siebach¹, M.M. Tice², J.A. Hurowitz³, E.L. Moreland¹, J.K. Van Beek⁶, T.V. Kizovskiy⁴, M. Schmidt⁴, L.P. O’Neil², A.H. Treiman⁵, A.C. Allwood⁶, M.L. Cable⁶, M. Nachon², S. Gupta⁷
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Introduction: The Mars 2020 rover *Perseverance* is exploring Jezero crater to collect a diverse suite of samples and characterize the geological and environmental context of those samples in anticipation of return to Earth via Mars Sample Return. The Western Delta in Jezero crater includes water-lain rocks from an ancient and diverse watershed that have been lithified and exposed by wind. We describe the chemistry of sedimentary rocks analyzed during the Upper Fan Campaign between mission sols 708 and 910 [1,2].

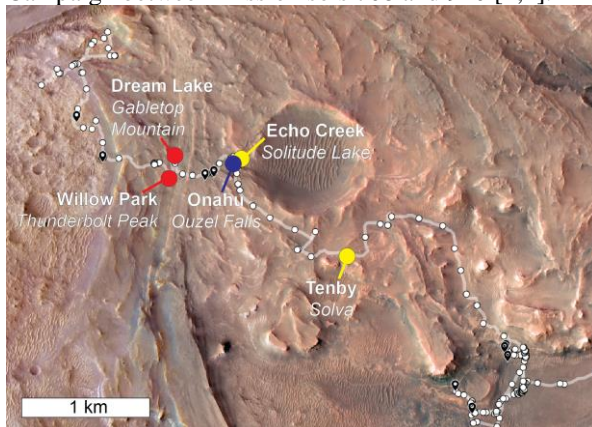


Figure 1. Map of rover traverse across the Western Delta in Jezero crater, showing the sites of the five sedimentary abrasion patches analyzed on the upper part of the delta. Outcrop and abrasion names shown.

Prior to landing, two distinct units were identified from orbit on the western delta: a curvilinear unit with alternating light and dark bands similar to fluvial scroll bars [3], and a blocky unit forming ridges and channels [4]. *Perseverance*'s ground-based observations revealed two facies associated with the curvilinear unit, described as the Tenby formation: the Skrinkle Haven member has alternating bands of light-toned resistant sandstone and recessive coarser grained materials that create the distinct orbital signature, and the Carew Castle member is an overlying cross-stratified coarse sandstone to conglomerate [5]. The blocky unit was primarily exposed as loose boulders, but outcrops of a coarse sandstone were found along two cross-cutting channels and are called the Otis Peak formation [6]. Tenby was sampled once and Otis Peak was sampled twice [7] and the lithologies were investigated in ~5 cm diameter abrasions. Here, we describe the average chemistry and sedimentary petrology of the units.

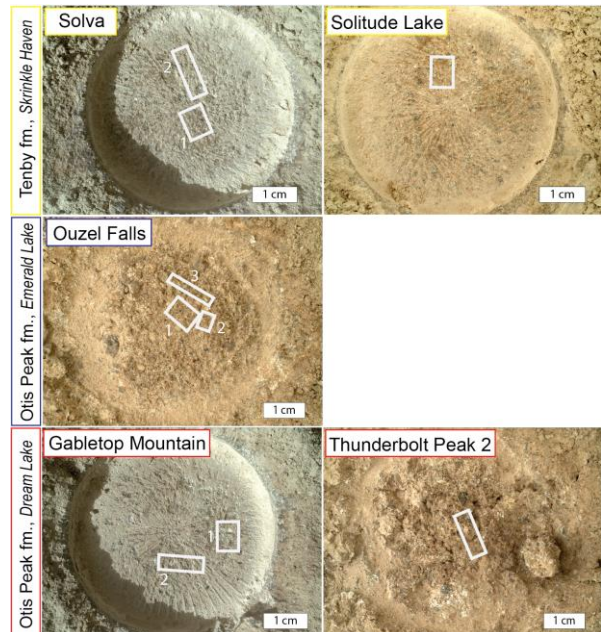


Figure 2. WATSON camera images of abrasion patches with white outlines showing areas of PIXL scans.

PIXL Instrument: The Planetary Instrument for X-ray Lithochemistry (PIXL) is a micro-XRF instrument mounted on *Perseverance*'s robotic arm that obtains maps of high-resolution (~120 μm spot size) geochemical data of rock targets [8]. We describe chemical results from nine scan maps (spot spacing ~120 μm) on five abrasion patches on sedimentary rocks. PIXL also chemically analyzed natural surfaces in this campaign [results in 9] and abraded and analyzed two distinct boulders between these scans [see 10,11].

Compositional Analyses and Results:

Skrinkle Haven Member. The light-toned bands of the orbital curvilinear unit were analyzed at Tenby and at Echo Creek. These are light-toned, erosion-resistant, laminated, poorly sorted medium sandstones. The detrital grains are basaltic and consistent with primarily olivine and olivine altered into phyllosilicates, with at least one grain of sodic plagioclase and possibly more fine-grained feldspar or augite. Light-toned rims around some detrital grains suggest an early carbonate cement [12]. Small spinels appear to be chromite-dominated. Fe-Mg carbonate is distributed throughout the scan and may act as a cementing agent along with minor Fe-Mg sulfates. The Solitude Lake scan had more carbonate and a wider range of feldspars than Solva.

Formation	Tenby	Tenby	Otis Peak	Otis Peak	Otis Peak
Member	Skrinkle Haven	Skrinkle Haven	Emerald Lake	Dream Lake	Dream Lake
Outcrop	Tenby	Echo Creek	Onahu	Dream Lake	Willow Park
Sample	Melyn		Otis Peak	Pilot Mountain	
Abrasion Name	Solva	Solitude Lake	Ouzel Falls	Gabletop Mountain	Thunderbolt Peak
PIXL Sol(s)	747, 751	782	789, 790, 811	879, 880	894
#PMCs	5670	2337	6495	4918	2581
SiO ₂ (wt%)	38.49 ± 1.50	34.66 ± 1.36	36.39 ± 1.50	36.66 ± 1.44	36.37 ± 1.50
TiO ₂ (wt%)	0.04 ± 0.01	0.10 ± 0.03	0.05 ± 0.02	0.04 ± 0.01	0.01 ± 0.01
Al ₂ O ₃ (wt%)	0.57 ± 0.19	1.20 ± 0.21	1.34 ± 0.28	0.79 ± 0.21	0.66 ± 0.21
FeO _T (wt%)	29.63 ± 1.12	27.24 ± 1.04	24.62 ± 1.00	27.29 ± 1.04	28.59 ± 1.15
MnO (wt%)	0.50 ± 0.17	0.44 ± 0.15	0.35 ± 0.15	0.42 ± 0.16	0.50 ± 0.17
MgO (wt%)	17.11 ± 0.82	18.43 ± 0.86	14.97 ± 0.84	17.85 ± 0.85	14.83 ± 0.81
CaO (wt%)	1.27 ± 0.25	1.58 ± 0.21	0.70 ± 0.20	2.53 ± 0.30	0.87 ± 0.23
Na ₂ O (wt%)	0.44 ± 0.47	0.65 ± 0.49	0.49 ± 0.56	1.12 ± 0.80	1.06 ± 0.94
K ₂ O (wt%)	0.01 ± 0.01	0.08 ± 0.02	0.02 ± 0.02	0.02 ± 0.01	0.01 ± 0.01
P ₂ O ₅ (wt%)	0.02 ± 0.01	0.15 ± 0.02	0.60 ± 0.13	0.24 ± 0.08	0.14 ± 0.10
SO ₃ (wt%)	1.70 ± 0.25	6.48 ± 0.43	6.36 ± 0.40	3.87 ± 0.32	3.62 ± 0.37
Cl (wt%)	1.64 ± 0.36	1.80 ± 0.36	2.20 ± 0.38	3.63 ± 0.39	2.27 ± 0.38
Cr ₂ O ₃ (wt%)	0.15 ± 0.03	0.16 ± 0.03	0.11 ± 0.02	0.16 ± 0.03	0.08 ± 0.02
NiO (wt%)	0.03 ± 0.02	0.04 ± 0.02	0.05 ± 0.02	0.04 ± 0.02	0.03 ± 0.02
ZnO (wt%)	0.03 ± 0.02	0.03 ± 0.02	0.03 ± 0.02	0.04 ± 0.02	n.q.
Sum	91.23 ± 2.27	92.67 ± 2.27	87.97 ± 2.41	94.36 ± 2.38	88.59 ± 2.59

Table 1. “Bulk” chemistry for the five abraded sedimentary rock targets analyzed by PIXL in the Upper Fan Campaign. Bulk chemistry obtained by averaging all PMCs (PIXL Motor Counts) of all scans on that abrasion patch after version 3.2 corrections for diffraction and roughness effects. Error obtained by averaging calculated error from all PMCs based on the same correction. Current working names for geologic formations and members listed.

Carew Castle Member. A poorly-sorted, cross-stratified, sandstone-pebble conglomerate interpreted to be deposited in a fluvial environment was analyzed on a small ridge called Powell Peak. The detrital grains include olivine and altered olivine (some stoichiometrically matching nontronite and sepiolite), altered lithic basaltic grains including plagioclase, an Fe-Mg carbonate clast, and small Cr-rich spinels. A unique Fe-phosphate was detected and is described in [13]. The matrix is complex and includes Fe-Mg carbonate, silica-rich material, Fe-Mg sulfate, phosphate, and possibly other phyllosilicates.

Otis Peak Formation. Outcrop exposed at the base of a trough previously mapped as delta “Lobe M” [14] was sampled at the Dream Lake locale and investigated again at the Willow Park area. It is a medium to coarse sandstone interpreted to be fluvially deposited in a late, cross-cutting episode of delta activity. These scans show detrital coarse altered olivine grains, minor augite, phyllosilicate alteration phases (including

stoichiometrically detected saponite, greenalite, and hectorite from the MIST model [15]), coarse chromite spinel, and minor Fe and Ca phosphates with an Fe-Mg carbonate, sulfate, and silica cement.

Summary: Upper Fan sedimentary rocks originate from a slightly altered olivine-rich basaltic protolith and are cemented by Fe-Mg carbonates, sulfates, and silica.

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References: [1] Siebach, K.L. et al. (2023) *AGU Fall Meeting* P41E-3232. [2] Nachon, M. et al., *this meeting*. [3] Caravaca, G. et al., *this meeting*. [4] Stack, K. et al., (2020) *SSR* 216(8). [5] Gupta, S. et al., *this meeting*. [6] Gwizd, S. et al., *this meeting*. [7] Weiss, B. et al., *this meeting*. [8] Allwood, A. et al., (2020) *SSR* 216:134. [9] Schmidt, M. et al., *this meeting*. [10] Moreland, E. et al., *this meeting*. [11] Treiman, A. et al, *this meeting*. [12] Tice, M. et al., *this meeting*. [13] Kizovski, T. et al., *this meeting*. [14] Kronyak, R., et al., (2023) *54th LPSC* 2067. [15] Siebach, K.L., et al. (2022) *IMA* #OL40_5.