***FALCON_LAKE*: AN OLIVINE-RICH BOULDER IN JEZERO CRATER, MARS.**

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Introduction: The Mars2020 *Perseverance* rover has explored the top of the western fan in Jezero crater to seek signs of ancient life and collect samples for return to Earth [1]. The fan top has distinct boulders and boulder fields, carried in by large flows from areas outside of Jezero crater [2,3,4]. Studying boulder composition helps characterize the Jezero watershed, aiding in provenance investigations for finer-grained rocks and/or helping identify crater rim units of interest.

The *Falcon_Lake* boulder was investigated (sols 839-853) as a representative of a remotely-sensed class of "olivine-rich" boulders, compared to the "pyroxene-rich" boulders [5,6]. The *Lake_Haiyaha* (LH) abrasion was performed on sol 849 (Fig. A).

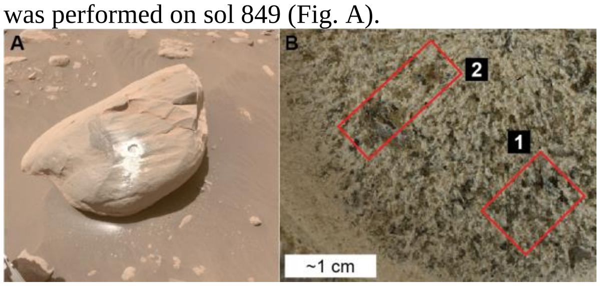

Figure A: A) Left Navcam image (sol 850) of *Falcon_Lake* with abrasion patch (5 cm wide). B) WATSON image of *Lake_Haiyaha* abrasion with two PIXL scan locations shown.

The olivine-rich nature of *Falcon_Lake* was reminiscent of the olivine-rich formation explored in the crater floor named the Séítah unit [7,8]. Comparing the boulder and crater floor lithologies may help us interpret if rocks with properties of the crater floor units are widespread in the Jezero catchment. While this work will focus on the Séítah unit, future work will consider the Máaz unit. Data on *Falcon_Lake* was acquired by multiple instruments including Planetary Instrument for X-ray Lithochemistry (PIXL), which obtained two element map scans on the *Lake_Haiyaha* abrasion patch on sols 851 and 852 (Fig. A). The PIXL scans from the Séítah unit on the crater floor were on the abrasion patches *Dourbes* and *Quartier*; two PIXL scans were performed on each patch on sols 257-270 and 294-301, respectively [7].

The PIXL Instrument: PIXL is a micro-X-ray fluorescence spectrometer that obtains high-resolution (~120 μm) geochemical data of rock targets [9]. Elemental abundances for all scans are quantified in PIXLISE using v3.2 formulae that correct for effects of diffraction and surface roughness [10,11].

MIST Algorithm: The Mineral Identification for Stoichiometry (MIST; mist.rice.edu) algorithm is based on geochemical stoichiometry, or testing whether element abundance and ratios fit into a mineral structure assuming a mono-mineralic area was measured [12]. This method works when the target is larger than the measurement spot size (for PIXL, ≳ 120 μm) so that the algorithm identifies spots of a pure mineral phase.

Geochemical Data: The bulk chemistry for the *Falcon_Lake* boulder (2 scans) and Séítah unit (4 scans) were retrieved as an average of the quantified chemistry of all scans in each respective unit (Table 1).

Table 1: PIXL bulk chemistry of *Falcon_Lake* and Séítah rocks

	Falcon_Lake			Séítah		
Na_2O	0.45	±	0.62	0.62	±	0.29
MgO	33.57	±	1.42	16.14	±	0.79
Al_2O_3	0.19	±	0.12	1.75	±	0.25
SiO_2	35.04	±	1.36	37.01	±	1.47
P_2O_5	0.02	±	0.02	0.25	±	0.03
SO_3	2.00	±	1.53	2.55	±	0.23
Cl	0.38	±	0.17	0.87	±	0.24
K_2O	0.01	±	0.01	0.13	±	0.04
CaO	0.40	±	0.13	3.45	±	0.29
TiO_2	0.01	±	0.00	0.22	±	0.05
Cr_2O_3	0.11	±	0.02	0.14	±	0.02
MnO	0.26	±	0.17	0.43	±	0.16
FeO	22.21	±	0.86	29.38	±	1.15
Sum	94.52	±	2.36	92.69	±	2.29

Visualizations: The *Falcon_Lake* and Séítah PIXL analyses can be viewed in a SiO_2 – Na_2O+CaO+K_2O (CNK) – FeO_T+MgO (FM) ternary diagram to highlight silicate mineral assemblages and alteration style of minerals (Fig. B). Further, the oxide chemistry of all points in a PIXL scan can be visualized in RGB (red, green, blue) diagrams in the PIXLISE software (Fig. C).

Results: PIXL chemical analyses of *Falcon_Lake* and Séítah show that they are different, chemically and mineralogically.

MIST Mineralogy Overview: The MIST algorithm indicates the Séítah unit has a wide variety of minerals, both primary [olivine ($Fo_{\sim 43\text{-}53}$), pyroxenes (avg. $Wo_{33.2}En_{40.7}Fs_{25.9}$), and feldspar ($An_{\sim 8}$)] and secondary [smectites and talc species]. The *Lake_Haiyaha* abrasion contains only two minerals based on PIXL stoichiometric detections: primary olivine ($Fo_{\sim 73\text{-}74}$) and secondary serpentine [$Mg_{2.43\text{-}2.56}$, $Fe^{2+}_{0.79\text{-}0.92})_3Si_2O_5(OH)_4$].

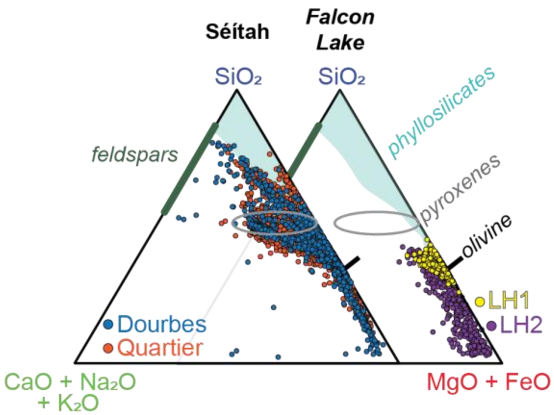

Figure B: SiO_2 – CNK – FM ternary diagrams (molar) with data points from Séítah and *Falcon_Lake*. LH = *Lake_Haiyaha* scans 1 (LH1) and 2 (LH2). The coloration of the data points corresponds to the different scans. General areas of mineral groups (pyroxenes, phyllosilicates, feldspars, and olivine) are labeled on the ternary diagrams. The text color at each apex corresponds to the RGB color mix in Fig. C.

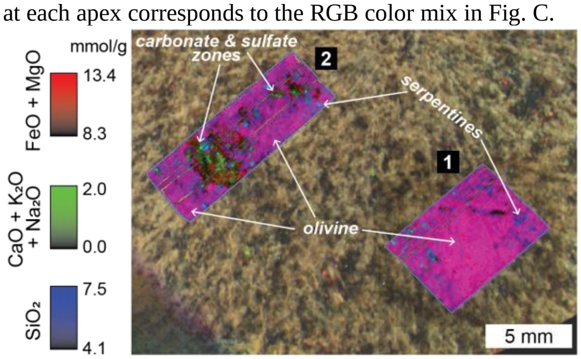

Figure C: PIXL element maps of *Lake_Haiyaha* scans (1 and 2 indicated) overlayed on an NIR-G-B context image of the abrasion patch. The element maps are presented as mixing of FM (red), CNK (green), and SiO_2 (blue) in mmol/g.

Primary Mineralogy: The Séítah rocks consist mostly of olivine, with lesser pyroxene and minor feldspar (Fig. B). Mineral assemblages and textures are consistent with olivine cumulates with poikilitic texture characterized by olivine ($Fo_{55\pm1}$) fully or partially enclosed by pyroxene ($Wo_{35–38}En_{43–44}Fs_{20–21}$) grains [7].

Falcon_Lake boulder has more limited primary mineralogy. The chemical data (Fig. B) indicate that the only primary mineral detected in *Lake_Haiyaha* was olivine ($Fo_{73\text{-}74}$), as suggested by the MIST results; no PIXL analyses fall in the pyroxene or feldspar areas of the plot. This is reflected in the RGB maps, where the magenta color indicates the dominant Fe-Mg primary silicate, olivine (Fig. C).

Accessory Mineralogy: Séítah has a diverse array of alteration minerals. Many points fall in the phyllosilicate region, with MIST indicating stoichiometric minerals such as nontronite, saponite, vermiculite, and minnesotaite (Fig. B). For a discussion of the confidence of mineral detections using MIST, see [13]. Other points trend toward the CNK and FM poles, indicating Fe-Cr-Ti oxide, Ca-phosphate, and minor alteration species such as Fe-Mg carbonate and Fe-Mg-Ca sulfate [7, 14].

Falcon_Lake has extremely limited alteration compared to Séítah, particularly in the LH1 scan area. The chemical data is tightly clustered around olivine (Fig. B & C), with little evidence for alteration minerals. MIST stoichiometry identifies serpentine, although this is distinct from interpretations from SuperCam [15]. The RGB map shows prevalent magenta and bluer regions (Fig. C), highlighting the Fe-Mg silicates (i.e., olivine and serpentine). LH2 reflects the trends in LH1 with chemically and visually dominant olivine and minor olivine alteration (Fig. B, C). LH2, however, has a slightly more complex mineralogy with a group of points trending more toward the FM pole and slightly toward CNK due to the zones with various Fe-Mg carbonates and Fe-Mg sulfates (Fig. B, C), with very minor phosphates and Cr-oxide.

Interpretations & Conclusions: Elemental data from the Séítah unit on the Jezero crater floor and the *Falcon_Lake* boulder show distinct primary and secondary (alteration) mineral assemblages. Séítah contains more diverse primary mineral species and phyllosilicates and is overall more Fe-rich. *Lake_Haiyaha* consists almost exclusively of Mg-rich olivine with very minor serpentine and patches of cross-cutting Mg-Fe carbonate and sulfate. The difference in primary mineralogy suggests that the rocks have different sources and petrogeneses; the difference in alteration species shows that Séítah and *Falcon_Lake* experienced differing degrees and/or conditions of alteration. Overall, PIXL data show that *Falcon_Lake* and Séítah are not directly related; *Falcon_Lake* represents a unique source terrain from outside Jezero crater and could be a fragment of the widespread olivine-carbonate unit beyond Jezero crater [16].

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References: [1] Farley et al. (2020) Space Sci Rev 216. [2] Cianciolo et al. (2024) this mtg. [3] Gwizd et al. (2023) AGU Fall Mtg P41E-3233. [4] Mangold et al. (2023) AGU Fall Mtg P43A-03. [5] Vaughan et al. (2024) this mtg. [6] Treiman et al. (2024) this mtg. [7] Liu et al. (2022) Science 377(6614). [8] Beyssac et al. (2023) JGR: Planets 128(7). [9] Allwood A. et al. (2020) Space Sci Rev 216(134). [10] Flannery et al. (2021) 43rd COSPAR #152. [11] Tice et al. (2023) 52nd LPSC #2659. [12] Siebach et al. (2022) IMA Mtg. #OL40_5. [13] Moreland et al. (2024) this mtg #1987. [14] Tice et al. (2022) Sci. Adv. 8(47). [15] Beyssac et al. (2024) this mtg. [16] Ehlmann et al. (2008) Science 322(5909).