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## A KOMATIITE SUCCESSION AS AN ANALOG FOR THE OLIVINE BEARING ROCKS AT JEZERO.

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**Introduction:** The Mars 2020 rover landed at Jezero crater on February 18, 2021 [1]. Since then, the rover has traveled around the “Séitah” region [2] and has collected data from the Mastcam-Z, Supercam, PIXL and SHERLOC instruments that has led to insights into the formation of the olivine-clay-carbonate bearing rocks that were identified from orbit [3,4]. Here we discuss three questions: 1) What have we learned about the olivine-clay-carbonate unit? 2) What terrestrial analogs exist for the unit? 3) Why do the rocks have a thinly layered morphology? We shall briefly mention instrumental measurements which provide important information regarding the olivine bearing rock at Seitah.

**Mastcam-Z:** The Mastcam-Z instrument obtains multispectral images extending to ~1020 nm. Images are being used to locate olivine via its absorption band centered near 1  $\mu\text{m}$ . Infrequent ropey textures suggestive of lava flows have been imaged by Mastcam-Z (Fig 1) [5].

**Supercam:** Supercam has been used to identify cumulate olivine and characterize its Fo# using Raman and LIBS measurements [6]. The Supercam VISIR data set is being compared to spectral features seen from orbit by the CRISM instrument on MRO [7]. Fig 2 shows a olivine-rich rock with a cumulate texture imaged by the Supercam RMI at Cine in Seitah.

**PIXL:** PIXL provides the elemental composition of its target via x-ray fluorescence at a resolution of ~120  $\mu\text{m}$  [7]. These data have now been used to identify at the millimeter scale cumulate olivine, high-Ca clinopyroxene and mesostasis (Figure 3) [8].

**SHERLOC:** SHERLOC UV Raman is being used for the identification of carbonates and olivine in a scanning mode and clays at a grid of points within the *in situ* FOV of the WATSON imager (Fig. 4) [9].



Fig. 1 MastcamZ image-sol 110 shows ropey textures of Tsa tsaadah

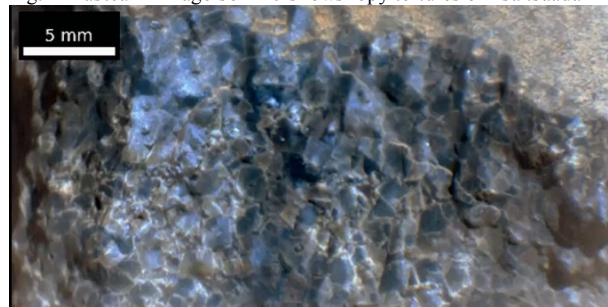


Fig. 2 Supercam RMI color stretched image (Cine sol 206) + blue cumulate olivine.

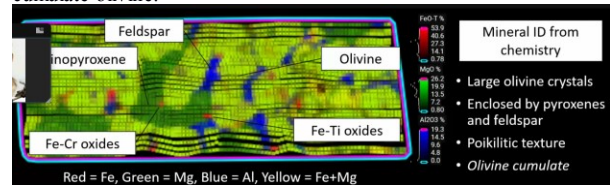


Fig. 3 PIXL (Dourbes sol 258). Green: olivine; dark green: augite; blue: mesostasis.

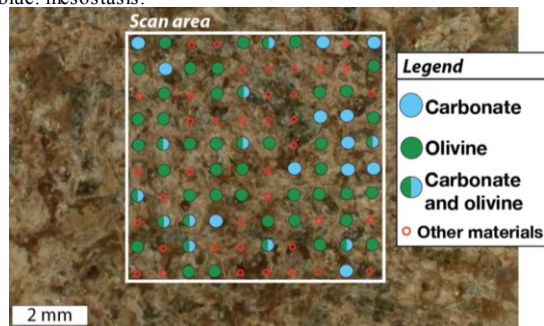


Fig 4. SHERLOC (Dourbes sol 292) showing olivine and carbonate

**What have we learned about the Olivine-clay-carbonate lithology?** The olivine-clay-carbonate lithology is among the best-documented rock types in Jezero crater and the surrounding watershed [3] and is potentially among the most astrobiologically compelling units in the region [10]. From orbital VNIR reflectance spectra, the unit contains abundant olivine (Fo#45-66) in large grains (>500  $\mu\text{m}$ , based on band saturation) accompanied by clay and carbonate minerals [3], and its crater retention age is  $\sim 3.82$  Ga [11]. Several potential origins of the olivine-rich unit are possible: 1) a density segregated melt associated with a lava flow or lake; 2) a pyroclastic density current (PDC) at low temperature [11]; 3) tephra fall [12]; or 4) some combination of all of the above, see also [13]. The transition from primary volcanic deposit to the olivine-carbonate-clay could have been from deuteric serpentinization and talc-carbonation [8] perhaps caused by late Noachian  $\text{CO}_2$  outgassing [14]. It is also possible that the olivine was altered to carbonate when it was exposed to a thick  $\text{CO}_2$ -rich Noachian atmosphere [15]. Discrimination between these formation and alteration histories is critical to advancing our understanding of Noachian mantle circulation [16].

**Terrestrial analog of komatiite sequence:** Here we consider a low viscosity lava flow or lake which density-segregated into a layered cumulate. Figure 5 shows two examples from the ultramafic Archean stromatolite-bearing Dresser Formation in Western Australia. Olivine replaced by serpentine and talc-carbonate are seen in a petrographic thin section in the image. Similarities with the olivine-clay-carbonate include the mm size cumulate textures and mineralogy, in this case the olivine is replaced by talc or serpentine.

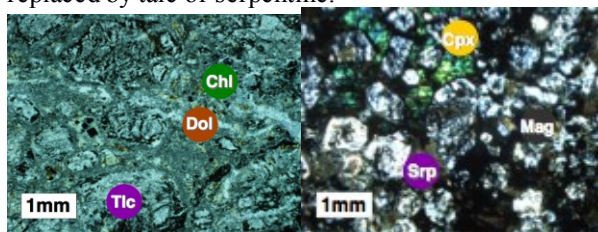


Figure 5 - Outline of approach for differentiating alteration styles of the olivine-carbonate lithology using M2020 instrumentation suite.

**Why such thin layering and polyhedral jointing?** Terrestrial komatiite sequence lavas have extremely low viscosity, and provide a starting indication for what the lava emplacement mechanism must have been for the olivine-clay-carbonate layers at Seitah and beyond in Nili Fossae. The thin layering (Fig 6) probably also contributes to the draping appearance of the unit reported in [12]. In addition, polyhedral jointing is also present at the top of many komatiite successions, including Dundonald Sill and is regarded as unequivocal evidence of an extrusive origin [18].

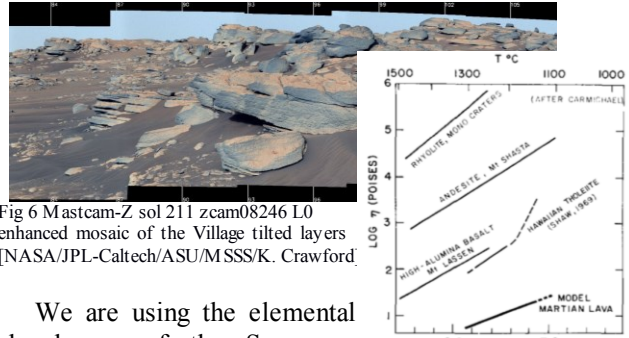


Fig 6 Mastcam-Z sol 211 zcam08246 L0 enhanced mosaic of the Village tilted layers [NASA/JPL-Caltech/ASU/MSSS/K. Crawford]

We are using the elemental abundances of the Supercam LIBS instrument to calculate the viscosity of the olivine-clay-carbonate unit at Seitah and will compare with our analog.

Fig 7 - Fig 8 of McGetchin and Smythe 1978 [17] showing viscosity of their model Martian lava which we suggest is similar to the olivine-clay-carbonate.

**Take away messages: 1)** We have outlined how the instruments of the *Perseverance* rover are being used to increase our understanding of this unit and determine their variations around Jezero. **2)** We have outlined the case for a komatiitic succession of rocks as an information-rich analog for the olivine-bearing rocks at Seitah. **3)** We are calculating viscosities for the olivine-bearing rocks and these indicate a low viscosity that may help explain the thin cumulate layering of these rocks.

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**References:** [1] Farley, K.A.+ (2020) SSR 216 [142](#) [2] Stack, K.M.+ (2020) SSR 216 [127](#) Sun, V. and Stack, K.M. USGS SIMap [#3464](#) [3] Ehlmann B.+ (2008) *Science* **322** [1828](#) Goudge, T.+ (2015) *JGR* **120** [775-808](#) [4] Brown, A. et al. (2020) *JGR* **125** [2019JE006011](#); Brown, A.J.+ (2010) *EPSL* **297** [174-182](#) [5] Bell, J.R.+ (2022) this meeting; Nuñez, J.+ (2022) this meeting; Johnson, J.+ (2022) this meeting [6] Wiens, R.+ (2022) this meeting; Pinet, P.+ (2022) *Icarus* [373](#); Udry, A.+ (2022) this meeting; Mandon, L.+ (2022) this meeting; Beyssac, O.+ (2022) this meeting; Poulet F.+ (2022) this meeting [7] Allwood, A.C.+ (2020) SSR 216 [134](#) [8] Schmidt, M.+ (2022) this meeting [9] Scheller, E.+ (2022) this meeting [10] Horgan, B.+ (2020) *Icarus* **339** [113526](#) [11] Mandon+ (2020) *Icarus* **336** [113436](#) [12] Kremer, C.+ (2019) *Geology* **111** [E02S10](#) [13] Ravanis, E.+ (2022) this meeting [14] Grott, M.+ *EPSL* **308** [391-400](#) [15] Pollack, J.B.+ (1987) *Icarus* **71** [203-224](#) [16] Hirschmann, M.M.+Withers, A.C. *EPSL* **270** [147-155](#) Kiefer, W.S. (2003) *MAPS* **38** [1815-1832](#) [17] McGetchin and Smythe J.R. (1978) *Icarus* **34** [512-536](#) [18] Arndt, N.+ (2004) *Journal of Petrology* **45** [2555](#)