THE FIRST REGOLITH SAMPLES FROM MARS.

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Introduction: The Mars2020 *Perseverance* rover is currently collecting samples within Jezero crater, Mars, to return to Earth - samples that will provide unprecedented new information about Mars [1]. These samples include igneous and sedimentary rocks, as well as unconsolidated sediments at the surface i.e. regolith. Regolith samples were collected Dec. 2 and 6, 2022 (sols 635 and 639) from a bedform within the Enchanted Lake region (Fig. 1). The samples were collected to enable the analysis of diverse materials ranging in size and composition that are too friable to be collected as intact rock, and that, together with the rock samples, form a sample suite that meets the goals of Mars Sample Return [2].

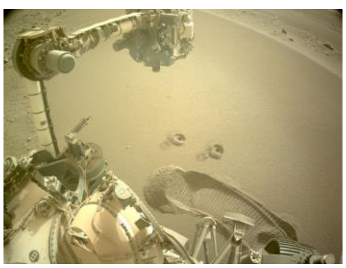

Figure 1. *Image of sampled megaripple on Mars, left = Atmo Mountain, right = Crosswind Lake. Image credit: NASA/JPL-Caltech*

The regolith samples were collected using a special regolith sampling bit, which contains two windows 8 mm x 7.4 mm [3], allowing material smaller than this size to be collected. Testing at JPL prior to sampling indicates maximum collection depth of 4-6 cm [4]. Stratigraphy and soil crusts (observed on the bedform) are not retained during regolith sampling, as sampling mixes the grains, but any cementing components and/or salts should be part of the material collected.

Location and characteristics of samples: The samples *Atmo Mountain* and *Crosswind Lake* were collected from the side of a megaripple known as Observation_Mountain, selected because it was a large, less mobile megaripple. CacheCam images taken of each sample in the tube prior to sealing and storage indicate the presence of both coarser and finer grained material (Fig. 2).

Analyses of regolith material: Previous missions showed that regolith at the surface differs from near-subsurface regolith [5, 6]. For this reason, a wheel scuff was generated in the ripple to allow analysis of subsurface materials in the scuff and tailings pile to complement analyses of undisturbed surface material and material compressed in a wheel track. These analyses comprise the "STOP" list for regolith samples [7].

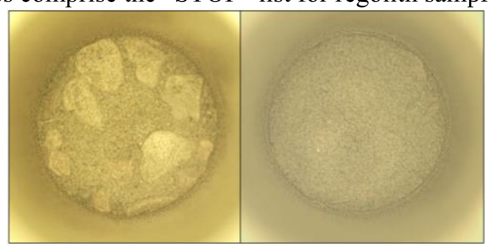

Figure 2. *Images of samples within the Cachecam, Atmo Mountain (left), and Crosswind Lake (right). Samples are ~13 mm diameter. Image credit: NASA/JPL-Caltech*

Mastcam Z Imaging. Imaging reveals the presence of a complex bedform crest, a surface soil crust similar to those observed elsewhere in Jezero crater [8], and the presence of coarse grains semi-armoring the bedform which is comprised mostly of finer-grained material.

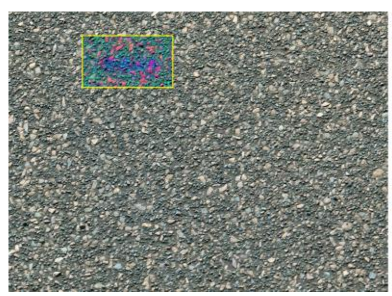

Figure 3. *Mastcam-Z left eye enhanced color with decorrelation stretch (inset; 754 nm, 528 nm, 442 nm) images at focal length 110 mm showing diversity of semi-armoring coarse grains present on the Observation_Mountain bedform. The dark strip is an area cleared of dust by the SuperCam LIBS measurements discussed below.*

Multispectral imaging shows the semi-armoring coarse grains to be quite diverse compared to what has been observed thus far along the traverse. There are smaller 1-2 mm grains, and lighter-toned, more irregular 2-5 mm grains with colors more similar to the local bedrock (Fig. 3).

SuperCam Analyses. SuperCam LIBS and VISIR measurements were collected of the undisturbed surface, the scuff tailings pile, the compressed track, the edge of the scuff, and the material disturbed as part of sampling. The fine-grained soils were very similar to those observed along the traverse. Most of the coarser grains were consistent with olivine, similar to other coarse grains observed at Jezero crater [9]. However, some grains in undisturbed areas included additional phases, likely from delta front rocks different from other observed grains in Jezero (Fig. 4), consistent with observations by Mastcam-Z; Fig. 3). In addition, much stronger absorptions at 1.9 µm (H_2O) and 2.3 µm (metal-OH) were observed in the pebbles and/or dark rounded granules of the undisturbed regolith than in the fine grains, suggesting that the most altered material is present in these coarse grains.

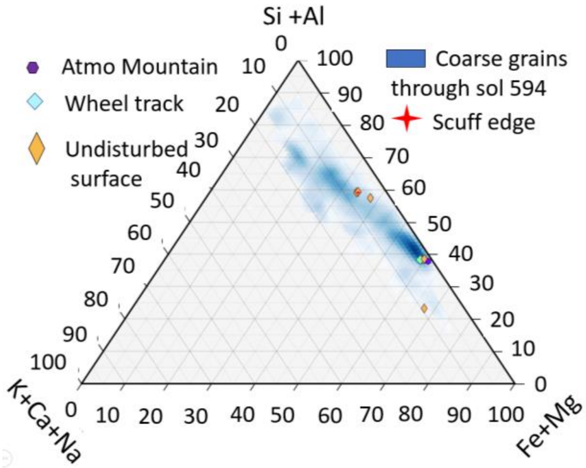

Figure 4. *SuperCam LIBS analyses showing that the undisturbed surface contains points that differ from most previous coarse grains (blue background) across Jezero crater.*

SHERLOC. SHERLOC Raman and fluorescence spectra were collected from the undisturbed surface and the tailings pile. The tailings pile contains features that can be assigned to phosphates, carbonates, sulfates, and possible olivine and quartz. In addition, fluorescence features at ~270 nm, 285 nm and 335 nm, which are consistent with single and double aromatic organics, were observed, although the ~335 nm feature might also be due to Ce^+. The fluorescence feature at ~335 nm was associated with the possible phosphate, while the fluorescence feature at ~270 nm was associated with the possible quartz detection.

The Raman signal intensity in the undisturbed surface was much lower than at the tailings pile, likely due to more topography and dust cover, and only possible olivine and quartz were detected in the spectra. Fluorescence features at ~285 nm and ~335 nm consistent with aromatics were detected in this target.

PIXL. PIXL analyzed the undisturbed surface and tailings pile with X-ray fluorescence to quantify elemental abundance and identify minerals. The undisturbed surface was dominated by large pebbles of olivine, altered olivine, probable carbonate, and aluminosilicate, with finer-grained materials also present. Subsurface material in the tailings pile was composed of fine-grained regolith similar to that observed on the undisturbed surface. Notably, the undisturbed surface was enriched in Cl compared to the excavated regolith, which has also been observed elsewhere on Mars [10], and may be related to perchlorate/oxychlorine salts.

Geophysical analyses. Thermal inertia (TI) values can be modeled using an effective particle size to describe the upper several millimeters to decimeters of surface material. Using this approach, the bulk particle size within Observation_Mountain is ~ 150µm. Atmospheric dust (~1-to 4 µm size) is not resolved in the model because the thermal conductivity of mixtures of grains tend to reflect the properties of the coarser bulk grains [11]. However, it is likely present in the sample, as also indicated by the initial shots of the SuperCam LIBS instrument [12] and WATSON analyses.

Conclusions and future work: In situ observations indicate that these samples include coarse grains semi-armoring the surface, the fine-grained material beneath the surface, as well as atmospheric dust. Mastcam-Z and SuperCam analyses indicate that the coarser grains are diverse relative to previous traverses, and likely reflect locally derived material. PIXL and SHERLOC analyses indicate minerals consistent with aqueous alteration, and SHERLOC analyses indicate fluorescence features consistent with single and double aromatic organics. Future analyses of these materials returned to Earth will allow a better understanding of surface sediments across Mars, as well as past aqueous and potentially biological processes on Mars.

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References: [1.] Farley, K.A., et al., (2020) *SSR*, **216,** 142. [2].Beaty, D.W., et al., (2019) MAPS. **54,** 667-671.[3]. Moeller, R.C., et al., (2021) *SSR*, **217,** 5. [4]. Goreva, Y., et al., in prep.[5].Sullivan, R., et al. (2008), *JGR-P., 113,* E06S07 [6]. Sullivan, R., et al. (2011), *JGR-P., 116,* E02006, [7]. Herd, C., et al. LPS LIV, subm. [8]. Hausrath, E.M., (acc.) *JGR-P.,* [9].Cousin, A., et al. LPS, LIV, subm. [10]. Yen, A.S., et al., (2005) *Nat.* 436, 49-54. [11]. Presley, M.A. and Christensen,P.R., (1997) *JGR-P.,* 102, 6551-6566. [12].Lasue, J., et al. LPS, LIV, subm.