MASTCAM-Z SPECTROPHOTOMETRIC OBSERVATIONS AT THE VAN ZYL OVERLOOK, JEZERO CRATER, MARS.

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Introduction: The Mastcam-Z stero imaging system on the Mars 2020 rover *Perseverance* acquired a set of visible/near-infrared (442-1022 nm) multispectral images at multiple times of day while parked at the Van Zyl Overlook (VZO) east of the landing site during Sols 63-65. These images sampled regolith, sands, rover tracks, and light-toned and dark-toned rocks over phase angles of ~0-150° that revealed wavelength-dependent changes in their scattering properties. Atmospherically-corrected radiance data will be used with future radiative transfer models to quantify the single-scattering albedo, phase functions, and microphysical characteristics of these materials [cf. 1].

Mastcam-Z description. Mastcam-Z [1] includes a pair of focusable, 4:1 zoomable cameras that provide broadband red/green/blue and narrowband 442-1022 nm color imaging with fields of view from 25.6°×19.2° (26 mm focal length at 283 μrad/pixel) to 6.2°×4.6° (110 mm focal length at 67.7 μrad/pixel). Each Mastcam-Z camera consists of zoom, focus, and filter wheel mechanisms and a 1648×1214 pixel charge-coupled device detector and electronics. The two Mastcam-Z cameras are mounted with a 24.4 cm stereo baseline and 1.65° toe-in on a camera plate ~2 m above the surface on the rover's Remote Sensing Mast (RSM), which controls azimuth and elevation actuation.

Data set. Mastcam-Z images were acquired as 2-frame mosaics at 34 mm focal length pointed in sunset and anti-sunset directions using left-eye filters centered at 800, 528, 442 nm (L156) and right-eye filters centered at 800, 866, 1022 nm (R126) at 7 times of sol with JPEG-85 compression (**Fig. 1; Table 1**).

Analysis. Mastcam-Z image calibration involved conversion of raw image data to radiance and relative reflectance via use of flat field images and onboard calibration targets [2,3]. Variations in spectral features as a function of phase angle were examined using spectral parameters such as the 528 nm band depth (*BD528*; sensitive to ferric crystalline materials), and the spectral slope from 800-1022 nm (*S16*; sensitive to dust coatings and ferrous minerals) (**Figs. 2, 3**).

Results. The largest spectral variations were observed in images acquired under near-zero or very high phase angles. This was particularly evident for dusty rock surfaces, which exhibited negative 528 nm band depths and stronger 800-1022 nm spectral slopes at higher phase angles (likely related to their smooth surfaces). Less dusty rock surfaces exhibited strong BD528 and S16 values at low phase angles. Strong BD528 values in rover tracks (resulting from exposed subsurface fines) weakened with increasing phase angle.

Some surfaces also included intermittent purple-hued patches that were enhanced at low phase angles and exhibited larger 528 nm band depths [5]. As such, their presence is less evident at higher phase angles often associated with arm-mounted rover camera images. There was also evidence for two types of “blue” rocks in the VZO area: One with partially dusty, indurated, and/or coated surfaces, and one that was more pristine, with prominent purple patches present and less dust. This may imply two distinct populations and/or different burial/exhumation histories within this portion of the Crater Floor-Fracture Rough (CF-Fr) unit mapped by [4].

Preliminary Conclusions. These multiple time-of-sol images emphasized the ubiquitous surficial dust patches that discontinuously coat sub-horizontal surfaces and partially fill micro-topographic depressions. Qualitatively, the relative scattering properties observed at VZO were consistent with materials observed at previous landing sites: Less dusty “blue” rocks, rover tracks, and darker sands exhibited dominantly forward scattering surfaces (likely with fewer internal microscale scatterers), whereas dusty “red” rocks and brighter, redder sands were dominantly backward scattering (with more internal scatterers). Future work will involve radiative transfer modeling required to quantify these variations and single scattering albedos [1].

References: [1] Johnson, J.+, JGR., 2005JE002494, 2006; Johnson,J.+,JGR, 2006JE002762, 2006; Johnson, J.+, Icarus, 248, 25-71, 2015; Johnson J.+, Icarus, 357, 114261, j.icarus.2020.114261, 2021; [2] Bell, J.+ Space Sci. Rev., 217:24, 2020; [3] Kinch, K.,+ Space Sci. Rev, 216:141, 2020; [4] Sun, V. and K. Stack, USGS map 3464, 2020; [5] Garczynski et al., this conf.

Table 1. Mastcam image sequences used in this work [listed as anti-sun, sunset sequences].

Sol	Sequences (zcam0####)	LTST (avg)	Phase angle (*g*) (°)*
63	3117,3118	08:20, 08:25	126,27
63	3117,3118	10:31, 10:36	99,48
64	3117,3118	13:21, 13:26	59,87
64	3117,3118	14:54, 14:59	37,110
64	3117,3118	16:07, 16:12	20,127
64	3117,3118	17:10, 17:15	9,143
65	3117,3118	11:22, 11:25	87,60

*LTST=Local True Solar Time; *average phase angle at mosaic center*

Figure 1. Mastcam-Z mosaic acquired at Van Zyl Overlook (Sols 53-64) showing locations of photometric image sets acquired in the sunset (*right*) and anti-sunset (*left*) directions.

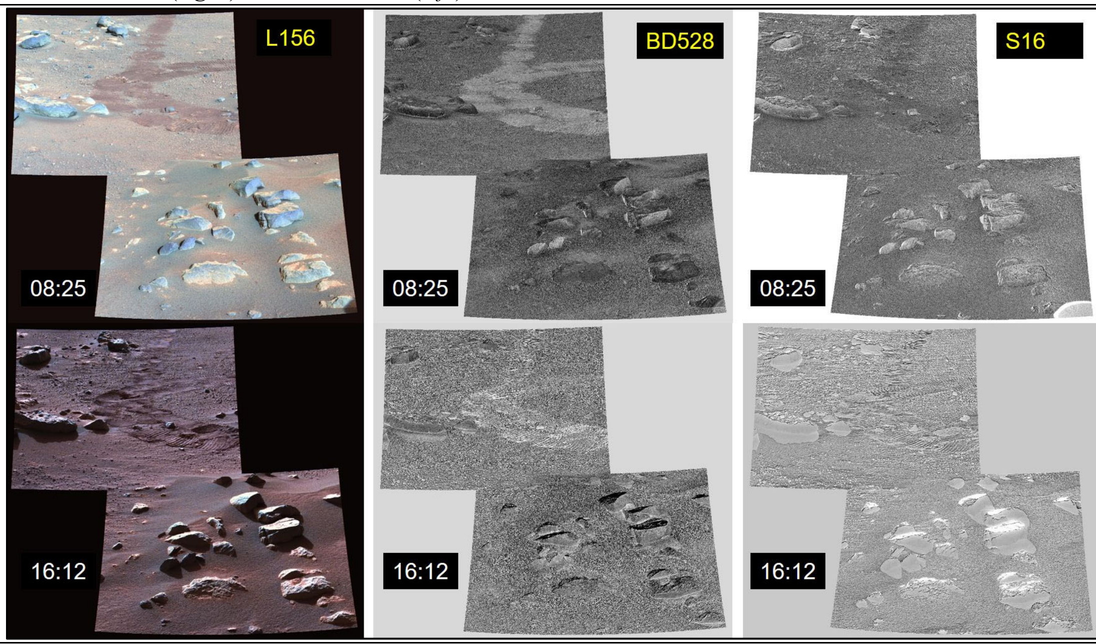

Figure 2. Examples of sunset-direction Mastcam-Z mosaics acquired at 08:25 LTST ($g \sim 27°$) and 16:12 LTST ($g \sim 127°$): enhanced color (445, 528, 800 nm: L156), 528 nm band depth (BD528; bright=deeper band) and 800-1022 nm spectra slope (S16; bright = more positive spectra slope).

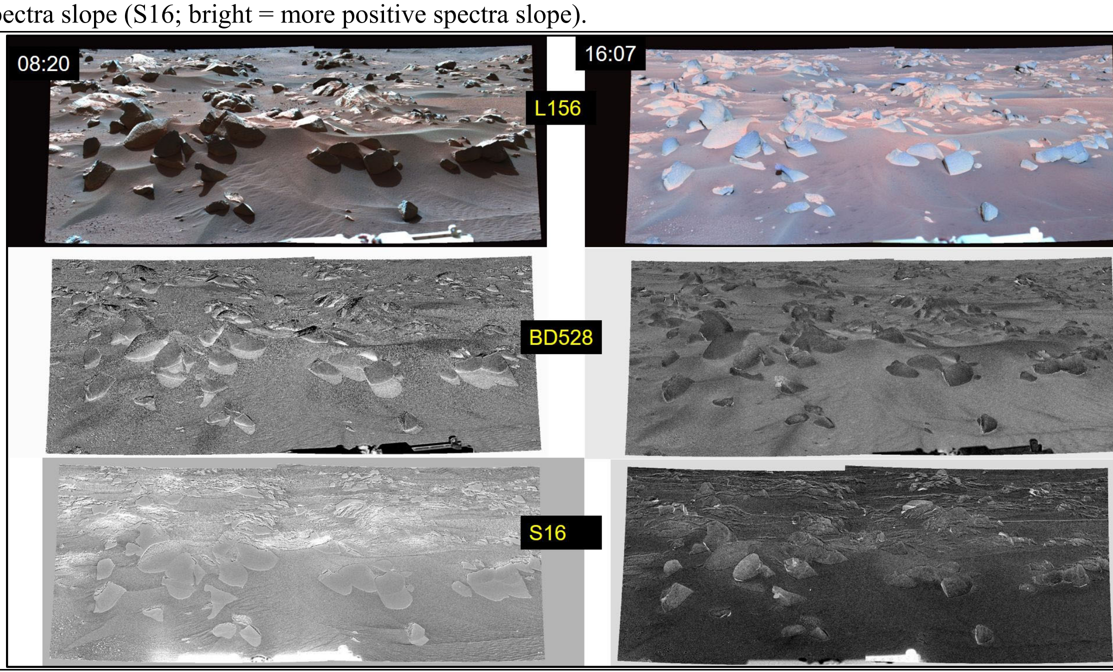

Figure 3. Anti-sunset direction Mastcam-Z enhanced color images, BD528, and S16 images acquired at 08:20 LTST ($g \sim 27°$) and 16:07 LTST ($g \sim 20°$). (Minor scattered light from rover observed in bottom of S16 frames.)