RECENT SPECTROPHOTOMETRIC OBSERVATIONS ALONG THE MSL AND MARS2020 ROVER TRAVERSES.
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Introduction: During the past year the Mars Science Laboratory *Curiosity* and Mars 2020 *Perseverance* rovers acquired new sets of visible/near-infrared (440-1020 nm) multispectral images at multiple times of sol from stationary rover locations to study the photometric properties of soils and rocks along the traverses (**Fig. 1**). On MSL, Mastcam and Navcam spectrophotometric data sets were acquired while the rover was parked at the drill targets Avanavero (Sols 3511-3530) and Canaima (Sols 3616-3618) on either side of Paraitepuy Pass. Mars2020 acquired a Mastcam-Z data set at Wildcat Ridge (Sols 520-525) in the Hogwallow Flats region. These images sampled bedrock, regolith, sands, rover tracks, and light-toned and dark-toned rocks over phase angles of ~0-140° that revealed wavelength-dependent changes in their light scattering properties.

Data sets. MSL Mastcam 34 mm focal length images were acquired using the 445, 527, 751, and 1012 nm (L1236) filters at 7 to 9 times of sol. Supporting Navcam stereo images were acquired to provide information on local surface facet orientations for future atmospheric corrections. Image locations and example enhanced color images are shown in **Fig. 2** (Avanavero) and **Figs. 3, 4** (Canaima). Also shown are phase color composite images, created by using the same wavelength (e.g., 751 nm) acquired at different phase angles, such that reddish areas are more backscattering compared to bluer forward-scattering areas (over the given phase angles sampled). Mars2020 stereo Mastcam-Z images were acquired using left-eye filters centered at 800, 528, 442 nm (L156) and right-eye filters centered at 800, 866, 1022 nm (R126) at 8 times of sol (**Fig. 5**). All images were acquired using lossless compression. Image calibration involved conversion of raw image data to radiance and relative reflectance via use of flat field images and onboard calibration targets [2,3,4].

Initial Results: MSL. At Avanavero, the bedrock exhibited subtle scattering variations related to discontinuous coatings of airfall dust and sands among areas of differing surface roughness. The background bedrock appeared redder in phase color composites (Figs 2c, 2e), suggesting a relatively more backscattering material. The bluer portions of the bedrock corresponded to areas with greater proportions of aeolian grains, whose forward-scattering nature was highlighted by the bluer nature of nearby, more extensive deposits of dark sands. Narrow light-toned veins crossing through the bedrock were the most backscattering, consistent with observations of such veins earlier in the MSL mission [e.g., 5].

At Canaima, the bedrock blocks were characterized by nearly planar laminations interrupted by sporadic concretion-like nodules, fragments, or coatings that were darker and less ferric (weaker 527 nm band depths) than the bedrock. The overall bedrock was predominantly backscattering, as suggested by the reddish nature of those surfaces in phase color composites (Figs. 3c, 3e). However, the embedded concretion-like materials were typically bluer (more forward-scattering) in those composites. Figure 4 notes examples of contrast reversals with phase angle associated with these materials, further emphasizing their forward scattering nature. Soils varied in their scattering properties depending on the amount of red, backscattering dust within the bedforms.

Initial Results: Mars2020. At Wildcat Ridge, the bright, crushed bedrock fragments exposed by rover wheel disturbances were extremely backscattering (red in the phase color composite in Fig. 5c) compared to undisturbed bedrock. Redder portions of fine-grained, naturally fragmented bedrock surfaces exhibited stronger backscattering than in-place bedrock (Fig. 5e). Dark, fragmented float blocks (likely derived from the Rocky Top outcrop north of Hogwallow Flats) were the most forward scattering (blue in the phase color composite, Fig. 5g), similar to the background dark sands (particularly the compressed soils within rover tracks, Fig. 5c). Rare examples of conglomeritic float blocks appeared intermediate in their scattering behavior, likely a consequence of their relatively rougher surface textures.

Conclusions. Multiple time-of-sol images at both rover locations emphasized that the variable light scattering properties of rock and soil units were overall a consequence of differences in surface roughness, grain size, composition, and the distribution of dust or sand coatings, similar to previous studies [cf. 1,6]. Ongoing work will use atmospherically-corrected radiance data with radiative transfer models to quantify the microphysical characteristics of these materials as a function of wavelength, including variability in phase reddening, single scattering albedos, phase functions, macroscopic roughness, and relative porosity/grain size distributions.

References:[1]Johnson, J.+, Plan. Space Sci., j.pss.2022.105563, 2022; [2]Bell, J.+, Space Sci. Rev., 217:24, 2020; [3]Kinch, K.+, Space Sci. Rev, 216:141, 2020; [4]Bell, J.+, Earth Space Sci., 4,396-452, 2016EA000219,2017;[5]Johnson, J.+, LPSC, #1354, 2018;[6]Johnson,J.+: JGR, 2006; 2005JE002494; JGR, 2006JE002762, 2006; Icarus, 248, 25-71, 2015; Icarus, 357, 114261, j.icarus.2020.114261, 2021.

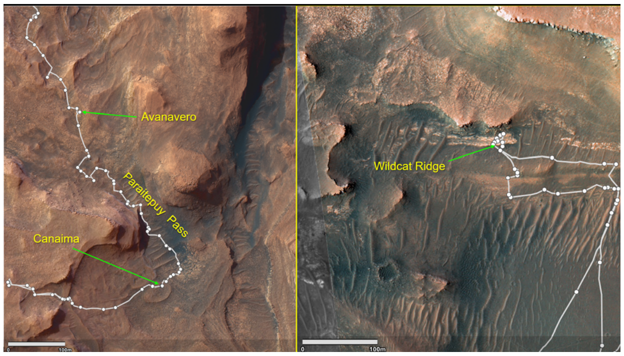

Figure 1. Locations of MSL (*left*) and Mars2020 (*right*) recent photometric campaigns shown on HiRISE basemap. White lines are rover traverse, dots are rover stops. Scale bars are 100 m.

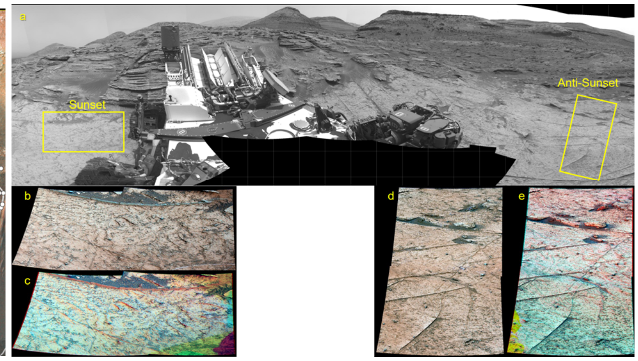

Figure 2. [*a*] Portion of Sol 3905 Navcam mosaic at the Avanavero site showing locations of enhanced color MSL Mastcam mosaics (RGB=751/527/445 nm) [*b,d*] and phase color composites at 751 nm taken a phase angles of RGB=13°/56°/84° [*c*] and RGB=41°/85°/114° [*e*].

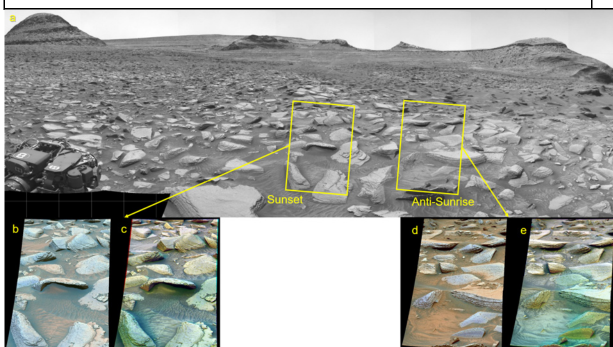

Figure 3. [*a*] Portion of Sol 3609 Navcam mosaic at the Canaima site showing locations of enhanced color MSL Mastcam (RGB=751/527/445 nm) [*b,d*] and phase color composites at 751 nm taken at phase angles of RGB=30°/55°/111° [*c*] and RGB=6°/46°/103° [*e*].

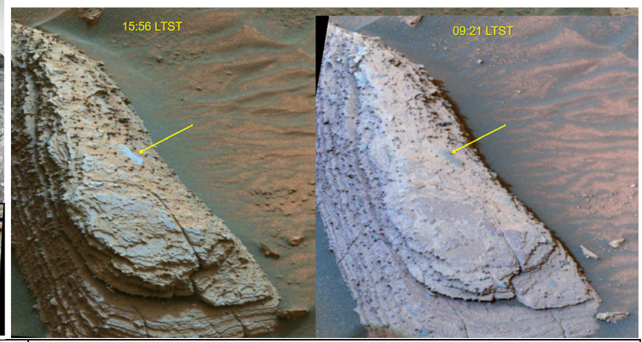

Figure 4. Comparison of MSL Canaima block in lower left of Sunset scene (Fig. 3b) acquired at phase angles of ~120° (15:56 LTST) and ~35° (09:21 LTST) showing contrast reversals in concretions within outcrop blocks (e.g., arrow).

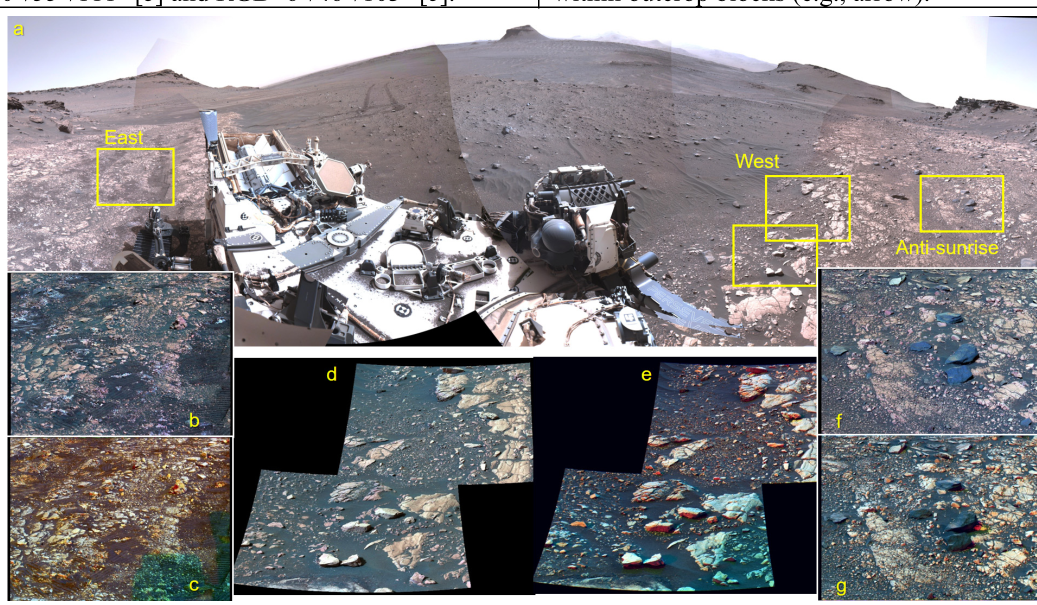

Figure 5. [*a*] Portion of Sol 531 Navcam mosaic at Wildcat Ridge site showing locations of enhanced color M2020 Mastcam-Z (RGB=800/528/442 nm) [*b,d,f*] and phase color composites at 800 nm taken a phase angles of 7/42/94° [*c*] (green area in lower right is shadow of camera head), RGB=46°/78°/106° [*e*], and RGB=15°/63°/91° [*g*].