APPLYING DS9 IMAGE ANALYSIS SOFTWARE TO DETERMINE DUST COVERAGES ON MAHLI ROCK TARGETS. I. K. Marincic[1], M. E. Schmidt[2], and T. L. J. Henley[3], Earth Science, Brock University, St. Catharines, ON L2S 3A1, Canada, imarinci@uwaterloo.ca

Introduction: The Martian surface is variably covered by a thin layer of airfall dust rich in S and Cl [1]. The dust affects in situ rock surface measurements, including textural interpretations in microscopic Mars hand Lens Imager (MAHLI) [2] images and elemental concentrations determined by Alpha Particle X-Ray Spectrometer (APXS) onboard the Mars Science Laboratory (MSL) Curiosity rover [3]. Dust is also visible in the Mars2020 SHERLOC WATSON microscopic imager and affects elemental compositions of unabraded rock surfaces by the Planetary Instrument for X-ray Lithochemistry (PIXL) [4]. Dust may be partially removed using the Dust Removal Tool (DRT), which is a motorized wire-bristle brush [5], and the ChemCam instrument, which utilizes Laser-Induced Breakdown Spectroscopy (LIBS) [3].

To quantify the amount of airfall dust present on rock surfaces in Gale crater, Schmidt et al. (2018) outlines three methods that utilize image analysis of the MAHLI images: Method 1 uses a greyscale image to select for dust, Method 2 utilizes the saturation of the image, and Method 3 uses Adobe Photoshop to color-replace selected dust pixels. VanBommel et al. (2016) also outlines a method for dust quantification using automated integration that allows for the removal of dust composition from underlying bedrock surfaces. Building on these techniques, we here present a new image analysis method to provide further percent quantification of airfall dust in microscopic images. The continuous development of new dust collection methods is necessary to justify dust quantifications in variable conditions including lighting, substrate color, texture, or topography. This method uses astronomical observation image analysis software DS9 [7] in conjunction with Adobe Photoshop and ImageJ [8] to measure dust-rich Martian surfaces. Target types include unbrushed as is targets as well as those that have had dust removed by the DRT, and ChemCam laser shots. The proposed method is here applied to MSL MAHLI, but could also be applied to unabraded rocks encountered by the Mars 2020 rover mission in Jezero crater.

Methodology: MAHLI images are obtained from the NASA Raw Images website [9]. The image with the highest Focus Motor Count (FMC) is chosen, and brought into BeFunky [10], to be edited. BeFunky is an online image editor that enhances and sharpens the raw image. The image is opened in Adobe Photoshop, which allows selection of dust pixels, identified by color value. The pixel is then changed to white using a color replace tool. The DS9 method uses Photoshop to select dark dust grains only. Dark dust is apparent on rock surfaces in shadows created by surface topography, or also present as a dark color due to the presence of magnetite in some dust particles [11].This image is then opened in DS9. The *Color* tool is then selected, followed by *red* to change the image to red scale. At the bottom of the window, there is a scale bar that ranges from 0-255, and a gradient from black to red. By right-clicking and dragging along the scale bar, features like light dust are selected, while features like shadows and bedrock are unselected. Once an appropriate amount of dust is selected from the image, the image is exported into ImageJ.
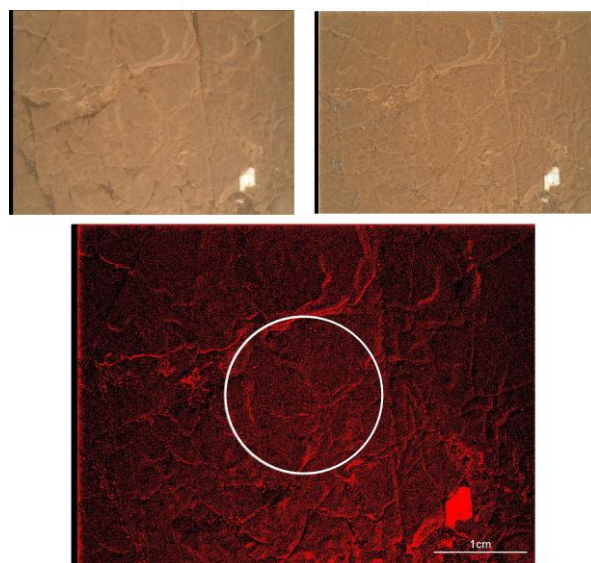
SOL 3020, LUNAS

*Fig 1. Mudstone rock type, full shadow **a**. Raw Image, **b**. Be-Funky and Photoshop edited image, **c**. DS9 and ImageJ edited image. Dust coverage percentage of 30.13% using DS9 method.*

Similar to steps outlined in Schmidt et al. (2018), ImageJ is able to provide a percent quantification of selected dust in an image. At the top of the window, *Image* is selected, then *Type*, and *8-bit*. This changes the image to black and white. *Process, Sharpen* is chosen to slightly enhance the 8-bit image. *Image, Adjust, Threshold* is then chosen to begin selecting dust present in the image. The threshold color bar is moved to the left, and dust pixels are gradually grabbed and highlighted red to show they have been selected. A percent quantification is then provided for the amount of highlighted pixels.

For comparison with APXS elemental compositions, the final dust quantification numbers are found using the *selection brush* tool to create a field of view (FOV) specific to each target. The FOV is placed at the centre of the image with a diameter found using the FMC correlated to each MAHLI image. An associated error accompanies the placement of the FOV due to spatial misalignment after switching from the MAHLI to APXS during documentation [6].

Application: We applied the DS9 method to a range of As Is, DRT, and ChemCam MAHLI rock targets (sols 1988-3160). Each target type disperses dust on the surface in differing ways which further demonstrates Method 4's efficacy.

Figure 2 shows how Method 4 dust coverage results compare to the average determinations by Methods 1, 2, and 3. The black line represents an $r^2 = 1$ trendline, indicating all points on or surrounding this trendline demonstrate the accuracy of collected dust using Method 4 in comparison to previously established methods. The uncertainty is ±5% when comparing the methods.
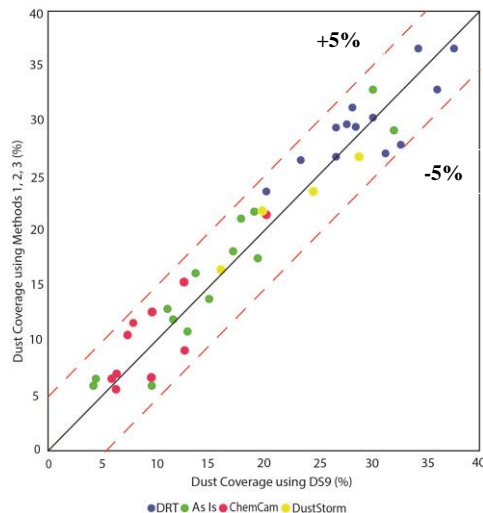

Fig 2. Dust coverage quantification of Methods 1, 2, 3 vs DS9 Method using DRT, As Is, ChemCam and MY34 Dust Storm Targets

Points are defined by target type (As Is, DRT, ChemCam) to show Method 4's ability to pick up dust from surfaces where dust accumulates in differing ways. All target types have demonstrated Method 4's ability to accurately pick up dust from each surface as no point on Figure 2 strays dramatically from the trendline. We also focused on As Is targets from the MY34 global dust storm event (sols 2101-2108) [12]. During dust storms, dust is suspended in the air, leading to increased opacity of the atmosphere causing rock targets to display more red hue. This affects lighting conditions present in MAHLI images, and inhibits our ability to differentiate dust from the substrate.

Nonetheless, dust storm dust coverages determined using DS9 are not significantly different from dust coverages determined by other methods. To further compare the methods, Figure 3 illustrates where the dust are identified differently using Method 3 [3] and DS9.
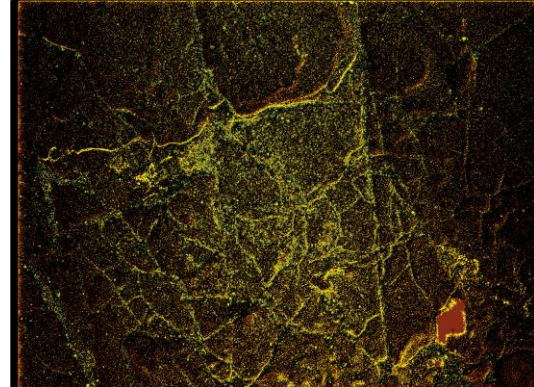

Fig 3. Method 3 and DS9 method overlap of dust collection. Method 3 is green, Method 4 is red, and yellow is where dust appears for both Methods 3 and DS9. Method 3 dust coverage of 32.3%, DS9 dust coverage of 30.31%.

Conclusion: DS9 provides a quick way to examine MAHLI images to obtain the dust coverage of a rock surface, as DS9 picks up light dust for the entire image at once. The inclusion of Photoshop with Method 4 comes from DS9's inability to pick up dark dust. Dark dust is less abundant on rock surfaces, making this step just as simple. With any method used to quantify dust on MAHLI rock targets, amounts of dust on a surface can be subjective, which is why the addition of this method only enhances the reliability of each method's final quantifications. Method 4 is capable of identifying dust on As Is, DRT, and ChemCam MAHLI rock targets. Any discrepancy in percent quantification is within the standard 5% range.

References: [1] Berger, J.A. et al. (2016) Geophys. Res. Lett. 43, 67-75. [2] Edgett, K.S. et al (2012) Space Sci Rev 170, 259-317. [3] Schmidt, M.E. et al. (2018) JGR 123, 1649-1673. [4] Allwood, A.C. et al. (2020) Space Sci Rev 216, 134. [5] Grotzinger, J.P. et al. (2012) Space Sci Rev 170, 5-56. [6] VanBommel, S.J. et al (2016) X-Ray Spectrom. 45, 155-161 [7] SAOImageDS9.com, https://sites.google.com/cfa.harvard.edu/saoimageds9 . [8] ImageJ.com, https://imagej.nih.gov/ij/download.html . [9] NASA Raw Images, https://mars.nasa.gov/msl/multimedia/raw-images/ . [10] BeFunky.com, https://www.befunky.com/features/photo-editor/ . [11] Goetz, W. (2005). Nature 436. 62-65. [12] Viudez-Moreiras, D. (2019) JGR Planets 124, 1899-1912.