ANALYSIS OF MARTIAN DUST COVERAGE AND CONTRIBUTION TO APXS ELEMENTAL CONCENTRATION FOR ROCK TARGETS IN GALE CRATER.

S.L. Bray[1], M.E. Schmidt[1], N.J. Bradley[1]. [1]Earth Sci, Brock Univ, St. Catharines, On L2S 3A1, Canada, sb13yz@brocku.ca, mschmidt2@brocku.ca, nb13qa@brocku.ca.

Introduction: Airfall dust is pervasive on the surface of Mars [1, 2, 3] and is a hindrance to our ability to interpret textural and geochemical properties of rock targets analyzed by the Curiosity rover. The Alpha Particle X-ray Spectrometer (APXS), which measures the outermost 2-200 µm of soil and rock surfaces [4], is one of the data sets more susceptible to dust interference. Dust coverages obtained through the analysis of Mars Hand Lens Imager (MAHLI) images have been found to correlate with light element concentrations, such as S and Mg [5, 6, 7]. The Dust Removal Tool (DRT) [8] is used to improve target surfaces for APXS analysis, but it does not completely remove dust. ChemCam is another method for clearing rock surfaces of dust. It uses Laser Induced Breakdown Spectroscopy (LIBS) in order to gradually ablate into target surfaces [9].

Our aim is to improve interpretation of APXS data by differentiating relative contributions of dust and bedrock to APX spectra, as well as to examine the effectiveness of current dust removal procedures.

Methodology: Adapted from methods detailed by Lee, et al. [5] and Bradley, et al. [6], MAHLI images of APXS targets were used to analyze dust coverages. Focus merge images were first opened in the free online photo editor called *Befunky.com* [10]. The image was sharpened and enhanced in such a way that the dust appears distinct from the bedrock. If shadows are present in the image, such as cast by the rover's arm, they are removed during this initial editing process. After the image has been edited, we use the *Replace Color* tool in Adobe Photoshop to gradually replace every colour value of dust with white. ImageJ is then used to convert to 8-bit greyscale and the *Threshold* tool is used to select the now white dust. The percent dust coverage is determined within a 1.7 cm-diameter circle centered on the MAHLI image to represent the APXS Field of View (FOV). APXS placement, including horizontal position relative to the MAHLI image as well as vertical standoff distance contribute uncertainty.

Results: We analyzed 199 rock targets (to sol 1511) in order to understand how dust behaves on the surface of Mars, as well as how it influences APXS data. Of the 199 targets, 118 are 'as is' (i.e., not brushed by the DRT), 63 are DRT, and 18 were blasted by the ChemCam laser prior to analysis (Fig. 1). As-Is targets ranged in dust coverage of 5.6% to 79.1% with a median value of 46.7%. DRT targets range from 1.2% to 57% dust coverage and have a median of 23.7%. ChemCam targets had dust coverages that ranged from 5.4% to 67.9% and a median value of 49.9%. These results indicate that the ChemCam is not an effective dust-clearing tool.

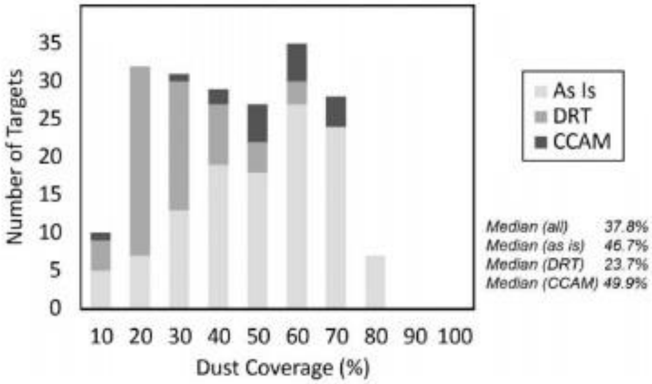

Fig. 1. The distribution of all analyzed rock targets, made up of As-Is, DRT, and ChemCam targets.

Quality of the DRT application depends on rock type; brushed mudstone targets have the lowest dust coverages, followed by nodular mudstones. Brushed sandstones have the poorest brush by the DRT as demonstrated by the highest dust coverages. Of the 63 DRT targets, 28 were mudstone and ranged in dust coverage from 1.2% to 28.4% with an average of 17.2%. Nodular mudstone DRT targets (n=18) range from 10.9% to 57% and average 25.5%. Sandstone DRT targets (n=17) have dust coverages ranging from 11.6% to 57% and had an average of 32.6% (Fig. 2).

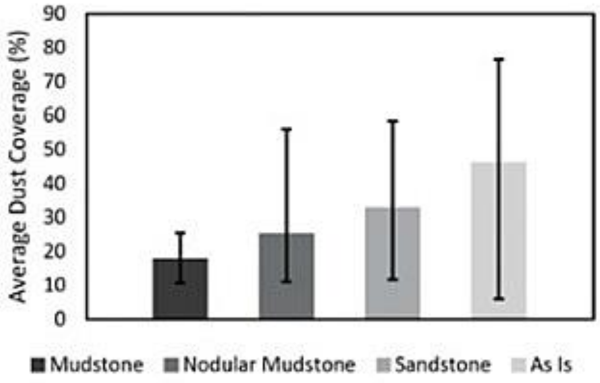

Fig. 2. Average dust coverages for DRT rock types. Error bars represent the range of dust coverages.

Comparison with APXS: Figure 3 displays the rock targets within the John Klein class (sol 129 to 291) plotted against the elemental concentrations of MgO and SO_3, as well as the SO_3/Cl ratio. This rock class was used because it is relatively homogenous and exhibits clear correlations between the dust coverage and bedrock compositions [11]. Dust coverage was found to correlate very well with the chosen elements; SO_3 and SO_3/Cl display positive trends (r=0.931 and 0.986, respectively), while MgO decreases with increasing dust coverage (r=-0.830). DRT targets can also be seen to have low dust coverages, which correlates with low amounts of SO_3 and high amounts of MgO. In each case, the targets trend towards the O-Tray dust composition established in Berger et al, 2016 [11].

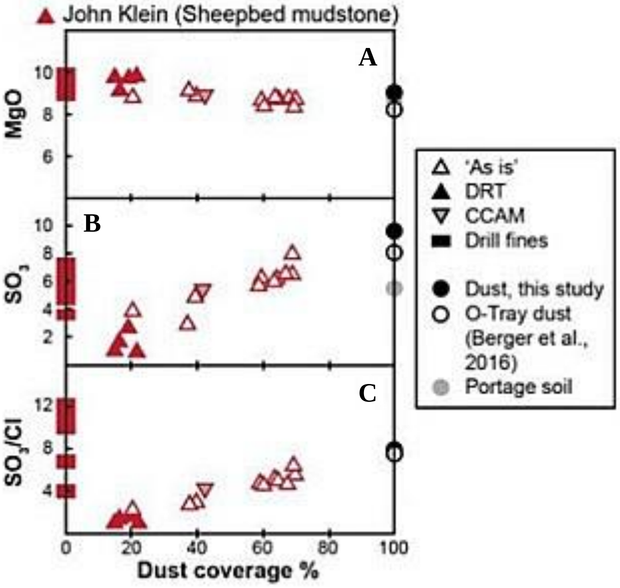

Fig. 3. Determined dust coverage plotted against John Klein compositions measured by APXS. A: MgO (wt%) vs. % coverage, B: SO_3 (wt%) vs. % coverage, C: SO_3/Cl vs. % coverage.

Discussion and Conclusions: Due to dust being nearly ubiquitous on Mars, it is important that it be taken it into account when analyzing data collected by Curiosity. We find that Martian dust noticeably impacts all APXS targets, including those treated by DRT and ChemCam, and that the dust coverages correlate best with homogenous rock classes, such as John Klein. As we have explored here, dust coverages can vary greatly depending on a number of factors, such as rock type and whether or not DRT has been applied (Fig. 4). Using MAHLI images, we can analyze this dust and compare the results to APXS data in order to visually see the impact that it has. Martian dust is high in SO_3 and Cl, which can be seen in the high correlation between the SO_3/Cl ratio, which means that rock targets with high dust coverages will have increased concentrations of these elements. Additionally, dust has a large effect on all light elements (Na to Ca) due to their interrogation depth being relatively shallow (<10 µm) [9].

Ackowledgements: This work was supported by a Canadian Space Agency MSL Participating Scientist grant to Mariek Schmidt.

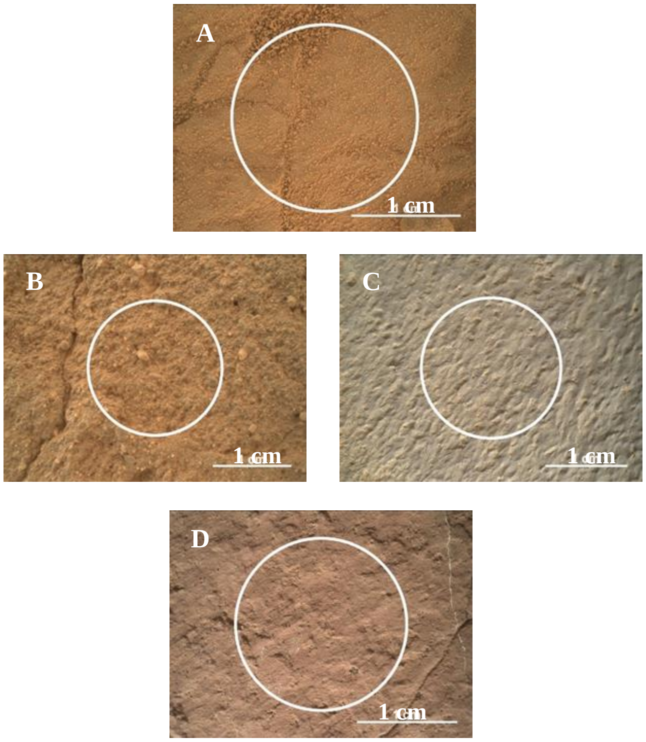

Fig. 4. MAHLI images of APXS rock targets of varying surface types. The circle in the centre of each image represents the assumed APXS field of view of 17mm [4]. A: Grit, sol 150 (0150MH0163000006R0_DXXX), dust coverage = 65% B: Big_Arm, sol 999 (0999MH0001630000204825R00_DXXX), dust coverage = 63.2% C: Augusta_DRT, sol 1157 (1157MH0002270000402460R00_DXXX), dust coverage = 14.8% D: Pemetic, sol 1511 (1511MH0001530000600045R00_DXXX), dust coverage = 8.5%.

References: [1] Edgett, K et al. (2012) Space Sci-Rev, 170, 259-317. [2] Gellert, R et al. (2006), JGR 111, JE002555. [3] Yen, A.S. et al. (2005) Nature 436, 49-54. [4] Schmidt, M.E. et al. (2014) *JGR* 19, 1-18. [5] Lee, R et al (2014) *LPSC* 2144. [6] Bradley, N et al (2017) *LPSC* 1662. [7] Bray, S.L. et al. (2017) LPSC 1670. [8] Davis, K et al. (2012) *Aerospace Mechanisms Symposium*, 41. [9] Schmidt, M.E. et al. (2017) Unpublished document. [10] Befunky.com, https://www.befunky.com/features/photo-editor/ [11] Berger, J.A. et al. (2016) *Geophys. Res. Lett.* 43, 67–75.