COMPARING AIRFALL DUST COVERAGES ON ROCK TARGETS AND APXS COMPOSITIONS BY THE MSL AND MER ROVERS: IMPLICATIONS FOR M2020 PIXL. M. E. Schmidt[1], S. M. Bray[1], N. Bradley[1], J. A. Berger[2] J. L. Campbell[3], T. L. J. Henley[1], G. M. Perrett[3], D. Tesselear[3] [1]Brock Univ. (St Catharines, ON L2S 3A1 Canada), [2]NASA JSC (Houston, TX 77058), [3]Univ. Guelph (Guelph, ON N1G2M7 Canada).

Introduction: Airfall dust, homogenized by global dust storms is abundant, variably scattered over Mars [1], and potentially influences all surface geochemical measurements. Observed in situ at rover landing sites, the dust is S- and Cl-rich, but otherwise basaltic [e.g., 2] and similar to estimates for average Mars crust based on surface compositions measured by Alpha Particle X-ray Spectrometer (APXS) [3].

In situ microscopic images and elemental concentrations determined by APXS onboard the Mars Science Laboratory (MSL) and Mars Exploration Rovers (MER) represent complementary datasets to assess dust on rock surfaces and its effect on composition. Importantly, dust-free rock is always visible in microscopic images and is therefore measurable by APXS. But dust remains a concern because: 1) procedures to remove surface dust by the MSL Dust Removal Tool (DRT) brush and MER Rock Abrasion Tool (RAT, includes a brush) have not been uniformly applied to rocks along rover traverses [e.g., 4]; 2) the quality of dust removal depends on smoothness of the rock surface [5]; and 3) the interrogation depths of the APXS (region where 90% of the observed X-rays originate) vary as a function of atomic number Z (2 to 80 μm for Na to Fe) [6].

Methods: We here expand the sol range of a previous MSL study (1504 to 1929; n=366) [5] that estimated areal percent dusty pixels in MAHLI (MArs Hand Lens Imager [7]) images by three methods: 1) brightness (grayscale), 2) saturation (color), and 3) color replacement (preferred). The maximum resolution for an APXS documentation MAHLI image is 17.1 μm per pixel, which is significantly larger than atmospheric dust particles (2.6 to 3.4 μm [8]). Dust coverage estimates by the three methods are generally within a few percent of one another, and error is thought to be ~5%. Dust coverages are then compared with MSL APXS analyses to aid in constraining dust-free compositions [5].

We also apply our grayscale analysis procedure (Method 1) to Microscopic Imager (MI [9]) images (31 μm per pixel) of APXS rock targets examined by the Spirit and Opportunity MER rovers in Gusev crater and Meridiani Planum, respectively. This work focused on paired MI and APXS observations of rock surfaces examined under multiple dust removal conditions, including 'as is', brushed (RB), and RAT-abraded (RR) surfaces and are available on the PDS (to sol 3993 [10]).

MSL Results: The overall range in dust coverage on APXS targets in Gale crater is 0.2 to 77%. Targets brushed by the DRT tend to have lower coverages, whereas the ChemCam laser does not significantly remove dust (Fig. 1). Dust coverages vary with elevation (Fig 2A); the lowest of which occur at approx. -4300 m, coincident with the Bagnold Dunes where active sediment transport was observed [11]. Variations in elemental concentration with elevation (e.g., MgO, Fig 2B) [12] do not correlate with dust coverage and reflect real variability in bedrock composition.

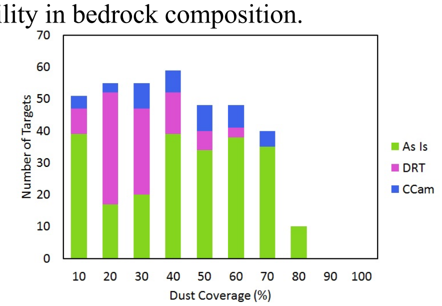

Fig 1. Histogram of MSL dust coverages (Method 3).

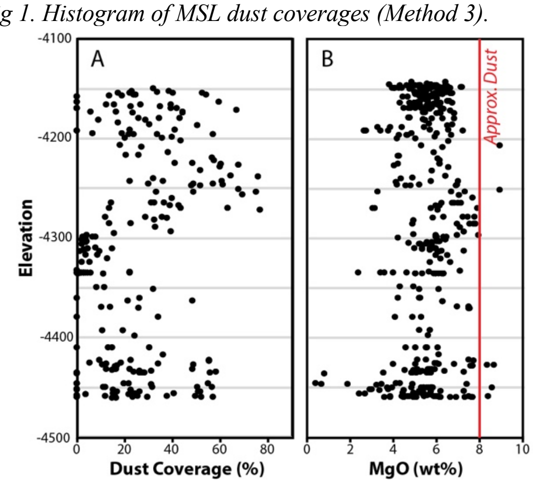

Fig 2A. Dust coverage and B. MgO with elevation for Murray

Comparing mudstones. Compositionally homogeneous groups of rocks demonstrate linear correlations between light element and S and Cl concentrations and areal percent dust coverage, trending to dust [2] at 100% coverage. This is well demonstrated by the Sheepbed mudstone (Fig 3A, B), where brushed, vein-free rock has low SO_3 abundances. Because the Sheepbed mudstone is similar in composition to average Mars crust [13], the influence of dust, while linear is actually minor and within the accuracy of APXS [6]. The effect of dust is more pronounced for rocks that are very different in composition from average Mars crust [5].

Relative to the Sheepbed mudstone, Murray Formation mudstone is compositionally more variable, likely owing to changes in provenance and overprinting by diverse diagenetic processes, including abundant Casulfate veining over its >300 m. of stratigraphy [14] (Fig 2B). Murray drill fines (DF) and low dust coverage rocks exhibit a wide compositional range, whereas dustier rocks tend to span a more narrow range approaching the composition of dust (Fig 3B, C).

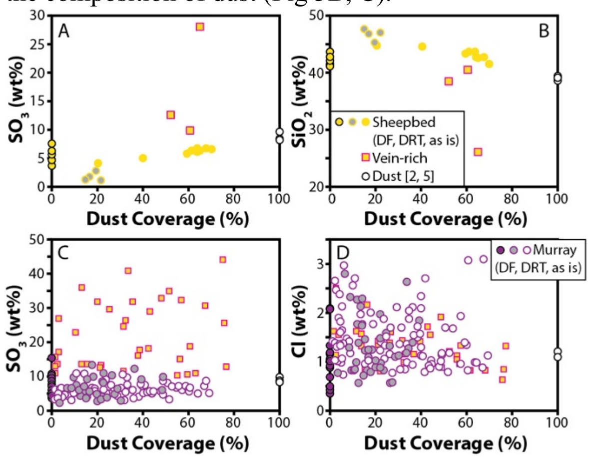

Fig 3A: SO_3 and B: SiO_2 vs. dust coverage for the Sheepbed mudstone. C: SO_3 and D: Cl vs. dust coverage for Murray Fm mudstones, excluding Pahrump Hills [14].

Modelling APX Yield. We compared paired DRT and 'as is' analyses (n=4) by APX Yield modelling to extract element concentrations from APXS spectra through a combination of least-squares fitting and application of the fundamental physics parameters, which describes the interaction of alpha particles and X-rays with the atoms in the sample. Estimates of dust coverage allowed determination of best fit dust thickness (generally ~10 µm) and of the dust composition (basaltic and similar to [2]). Although the dust is patchy with variable thickness, the lighter elements Na to Ca (interrogation depths <10 µm) are likely to be affected by dust. Therefore for homogeneous groups of rocks, linear correlations between dust coverage and light elements (Fig. 3A, B) allow us to estimate dust-free rock compositions. It is unknown where heavy element x-rays are generated and are therefore assumed to be from the rock, unless clear correlations with dust coverage are observed [5]

MER Results: The overall ranges in dust coverage on APXS rock targets observed by the MER Spirit and Opportunity are similar (15 to 61% and 20 to 67%, respectively). The lower resolution and grayscale of the MI images leads to a higher degree of uncertainty associated with these estimates. Even so, homogeneous groups of rocks, such as the Meridiani Burns Fm., tend to form linear trends in plots of elemental concentration vs. dust coverage (Fig. 4), spanning dust and the RAT abraded (RR) rocks. Elemental compositions in heterogeneous rock groups, including rocks exposed around Endeavour crater in Meridiani (Fig.4) and the Gusev suite (not shown) do not have linear correlations.

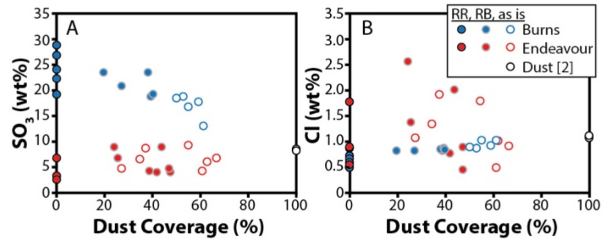

Fig. 4A. SO_3 and B. Cl vs dust coverage for Meridiani targets.

Implications for PIXL: Finally, we discuss how dust will impact interpretation of Mars 2020 PIXL (Planetary Instrument for X-ray Lithochemistry) results. PIXL utilizes a 100 µm-diameter, high-flux X-ray beam that can scan across target surfaces to characterize fine-scale geochemical variations [15]. Puffs of compressed air will blow dust from rock surfaces, but some dust is likely to remain on rock surfaces, particularly if the surface is uneven. The interrogation depth dependence on Z of the APXS will similarly be a factor for PIXL.

PIXL spots analyzed on Mars with dust-like SO_3 and SO_3/Cl may be attributable to dust, and may be either omitted or corrected for light and volatile element abundances when calculating bulk rock compositions. Cross-comparison with microscopic images taken by SHERLOC/WATSON [16] may verify the presence of dust on these spots, particularly if the level of uncertainty for S or Cl is high. Heavy elements critical for the identification of trace phases with potential for radiometric age dating and a high value for sample selection (e.g., Zr in zircon) are detectable in dusty rock surfaces.

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