CURIOSITY'S TRAVERSE TO MOUNT SHARP: ENHANCING SCIENTIFIC INVESTIGATION WITH HYPERSPECTRAL ORBITAL DATA.

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Introduction: The scientific exploration of Mars has greatly benefited from the synergy between targeted observations by ground-based rovers and large scale orbital datasets covering broad areas. For example, normal 18 m/pixel and 4 m/pixel oversampled orbital Compact Reconaissnace Imaging Spectrometer for Mars (CRISM) observations over Endeavour Crater reveal Fe/Mg smectites within the crater's rim, and Opportunity's campaign in this area has shown these clays are within a specific locality dominated by Whitewater Lake outcrops [1, 2]. Combining the orbital and rover-based datasets has consequently allowed for a more comprehensive interpretation of the geologic setting of the Endeavour crater rim than would be possible with each individual data type.

Curiosity's scientific exploration of Gale Crater and Mount Sharp will similarly benefit from synergies between orbiter and rover data. Here, we interpret CRISM observations over Curiosity's likely traverse from Bradbury Landing to the layers at the base of Mount Sharp, and describe how they may be combined with Curiosity's observational campaign to better understand the geologic history of Gale Crater. In places where the dust has been removed either by natural or artificial means, CRISM data reveal several distinct mineralogies that Curiosity will able to investigate in situ. This work will be a basis for continued discussion by the Curiosity science team.

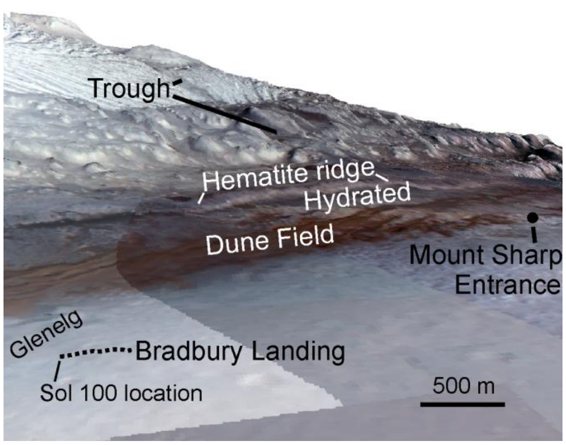

Figure 1: CRISM false color mosaic (R: 2.6 μm, G: 1.5 μm, B: 1 μm) of Bradbury Landing and lower portion of Mount Sharp overalin on a 2x vertically exaggerated DEM. Mosaic available at http://crism.jhuapl.edu/msl_landing_sites/

Bradbury Landing and surrounding areas: CRISM data covering Curiosity's landing site at Bradbury Landing and the hummocky unit traversed by the rover during its first 100 sols (Fig. 1) show no distinctive mineral signatures other than ubiquitous nanophase iron oxides typical of dusty areas (Fig. 2). Whereas CRISM data are sensitive to the uppermost few micrometers of the surface, relatively high Thermal Emission Spectrometer (TES) thermal inertia measurements from the same area suggest the dust thickness must be less than the diurnal skin depth of a few centimeters [3]. This orbital based interpretation is enhanced by MARDI and Mastcam observations at Bradbury Landing that show the coating of dust that dominates the CRISM observations was thin enough to be blown away by exhaust from the sky crane system (Fig. 3). Here, the thruster impingement zone has allowed us to better understand the distribution of material dominating the CRISM observation. ChemCam observations of rocks and soils from multiple locations along Curiosity's traverse in the hummocky unit also consistently show spectra characterisitic of dust in the first few LIBS shots of each observation [4] whereas this dusty signature quickly disappears once this coating is ablated by the laser. By extrapolating Curiosity's fine scale observations to nearby areas that appear to be similarly dust covered from in CRISM, we conclude much of the region in the vicinity of Bradbury Landing and on the way to the base of Mount Sharp will be blanketed by this thin coating of dust.

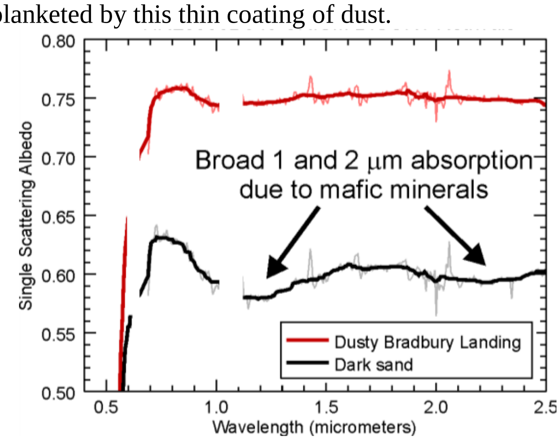

Figure 2: Representative single scattering albedo (SSA) spectra from HRL0000D349 for dusty areas at Bradbury Landing and dark sand dunes. SSA spectra were retrieved using DISORT radiative transfer procedures to model aerosols, gases, and Hapke function surface scattering [5].

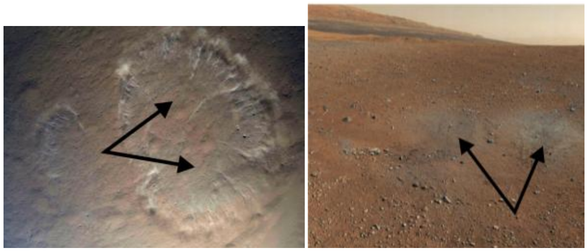

Figure 3: Left - MARDI image showing the thin layer of dust being removed from Bradbury Landing by the sky crane thrusters. Right - Mastcam of Bradbury Landing showing the same area post-landing. Note the color difference between the disturbed, less dusty soil than the typical dust covered area of Bradbury Landing.

Mount Sharp dune field: The dune field at the base of the Mount Sharp is the area closest to Bradbury Landing that shows distinctive mineralogical signatures in the CRISM observation (Fig. 1). The reason for these signatures is likely related to the fact that the dune field is active [6], and hence aeolian transport processes keep dust cover low. This allows us to gain more information about this area from CRISM data alone, which show the dunes are spectrally dominated by a mixture of pyroxenes and olivine, with some iron oxides possibly present as well (Fig. 2). In addition, the tranverse dunes in the south-eastern edge of the dune field have both olivine and pyroxene spectral signatures whereas the Barchan dunes along the north-western edge are dominated primarily by olivine signatures.

Curiosity's investigation of this area will allow for a better understanding of the structure and compositional diversity of the dunes than CRISM observations alone. Mastcam multispectral observations will illuminate heteogeneties in the dune field at scales smaller than the nominal 18 m/pixel CRISM resolution. ChemCam LIBS observations can assess the chemical diversity of the dunes, and MAHLI will allow for the characterization of grain size distribution; both these types of observations will occur in only a few, carefully selected locations. MAHLI and ChemMin observations of <150 micrometer sized particles can also be used to assess how the specific mineral phases are distributed within this smallest fraction size. All of this information will be important in building self-consistent models of the formation, sediment origin, degree of weathering, and modern day evolution of the dune field. CRISM spectra from this dune field are similar to CRISM spectra from dark areas higher up in the mound. It is also likely that the material encountered here by Curiosity will be present at multiple locations throughout lower Mount Sharp.

Lowest layers in Mount Sharp base: Unlike the spectrally featureless plains near Bradbury Landing, the lowermost strata at the base of Mount Sharp show distinctive spectral signatures indicative of hydration, iron oxides, clay minerals, and sulfates [7, 8]. That we can see mineral signatures in these strata indicates the base of Mount Sharp is not completely covered by the same dust layer observed at Bradbury Landing. Instead, katabatic winds blowing down Mount Sharp through a trough near this location (Fig. 1) may keep the surface compariatively dust free and visible to CRISM. The trough also implies this is an area of enhanced erosion.

The finely layered strata near Curiosity's expected entrance point at the base of Mount Sharp (Fig. 1) are associated with an absorption feature near 1.9 micrometers, indicative of hydration [6], although the CRISM data do not reveal information about specific mineralogy of these layers. CRISM data also show a hematite signature associated with a ridge located immediately above the hydrated strata (Fig. 1) [8]. This signature is not pure hematite and there are likely additional mineral phases within the ridge, such as olivine. Multispectral Mastcam observations can be used to remotely map the distribution of hematite within the ridge at a finer scale than CRISM and will be essential for determining a location for more study using Curiosity's other instruments. Mastcam multispectral images may also be used to remotely map the locations of hydrated minerals in this region at a more detailed scale than CRISM. Targeted observations with ChemCam (active and passive modes), can be used to delineate distinctive geochemical units at <18m per pixel scale [9]. Detailed investigations of areas identified by Mastcam and ChemCam with MAHLI will reveal fine-scale textures, which can be used to discriminate the hematite and hydrated mineral formation processes. Samples delieved to ChemMin and SAM can be used to characterize the associated mineral phases, which is also essential for determining hematite and hydrated mineral formation mechanisms and the environments of aqueous alteration.

References: [1] Arvidson, R.E. and Catalano, J.G. (2012) *AGU Fall Meeting.* [2] Arvidson, R. E. et al., (2013), this volume. [3] Fergason, R. et al. (2012) *Space Sci. Rev., 107, 739-773.* [4] Blaney, D. et al., (2013), this volume. [5] Arvidson et al., 2011, JGR doi:10.1029/2010JE003746. [6] Silvestro, S. et al. (2012) 43rd *LPS*, Abstract #1804. [7] Milliken, R.E. et al. (2009). *GRL*, 37, L04201. [8] Fraeman, A.A. et al. (2012) *AGU Fall Meeting.* [9] Johnson, J.R. et al., (2013), this volume.