ADVANCED CRISM PROCESSING RESULTS AND IMPLICATIONS FOR CURIOSITY'S TRAVERSES ON MOUNT SHARP. J. R. Christian[1,2], R. E. Arvidson[1,2], and K. E. Powell[3,4], [1]Department of Earth and Planetary Sciences, [2]McDonnell Center for the Space Sciences, Washington University in St. Louis (jchristian@wustl.edu), [3]Department of Physics & Astronomy, Northern Arizona University, [4]School of Earth & Space Exploration, Arizona State University

Introduction: Our WUSTL processing pipeline [1,2,3] for hyperspectral image data acquired with the Mars Reconnaissance Orbiter's (MRO) CRISM instrument (0.362 to 3.92 µm, [4]) models atmospheric contributions and the Hapke function [5] to convert from I/F values measured by the instrument to an estimate of surface single-scattering albedos (SSA). SSA is a measure of surface scattering efficiency independent of atmospheric conditions, lighting, and viewing geometries. We also use a neural network approach to model the mixed solar reflection and thermal emission portion of the CRISM data for wavelengths >2.65 µm [6]. In this abstract we apply these techniques to CRISM data over Mount Sharp for regions traversed and to be traversed by the Curiosity rover, with a focus on the detailed characteristics of the sulfate-bearing strata [7]. We also introduce the concept of back-projecting high resolution topographic data to CRISM sensor space to populate local incidence and emergence angles, which are used in radiative modeling to retrieve slope-corrected SSA spectra and surface kinetic temperatures (SKT) at 12 to 18 m/pixel spatial scales.

SSA Retrieval and Regularization Over Mount Sharp: CRISM scenes FRT0000B6F1 and FRT000248E9 (and ATO) covering the northern portion of Mount Sharp traversed and to be traversed by Curiosity were processed using our pipeline. The DISORT radiative transfer code was used to remove gases and aerosols and retrieve SSA spectra, then a log maximum likelihood algorithm was used to retrieve the best estimate of the SSA spectra in the presence of Poisson-dominated noise [1,2,3]. Our neural network was used to retrieve SKT and SSA values at long wavelengths. Illustrative results are shown in Figs. 1, 2 and described in the caption for Fig. 1. In addition, relatively high values of the 3 µm integrated band depth (Fig. 2), indicative of hydrated phases, can be seen in Glen Torridon, where CRISM data also show evidence for ferric smectites based on a 2.3µm absorption [8]. Several other areas of enhanced hydration are also evident in regions to the north traversed by Curiosity and also associated with selected strata on Mount Sharp above Glen Torridon. Results shown in the Figures will help define Curiosity's traverses.

High Spatial Resolution Local Incidence and Emergence Angles: Although our pipeline utilizes local incidence and emergence angles on a pixel by pixel basis the results are compromised by use of MOLA-based slopes to compute these values. The intrinsic individual pixel size for projected CRISM data is ~18 m. On the other hand MOLA gridded data have pixel sizes ~250 m. Thus there is a large spatial difference between the two data sets and only broadly varying angles can be computed (Fig. 3). We have thus also pursued use of a 6 m/pixel DEM generated from MRO Context Image data and provided courtesy of Michael Malin, MSSS. Specifically this high resolution DEM was used to compute local incidence and emergence angles at a spatial scale equivalent to CRISM pixels, and then back-projected onto the CRISM sensor space to use in our pipeline processing.

The DEM was first coregistered to CRISM FRT0000B6F1 projected data using an orthorectified CTX mosaic generated as part of the MSSS stereo pipeline. Slope angles at each CRISM pixel were estimated from the gradient in the DEM calculated through second-order finite differences [9], and the surface radius at each CRISM pixel was estimated from MOLA data. The direction of the sun (accounting for surface curvature) and direction of MRO (accounting for the motion of the spacecraft as the observation was made) were then determined. The angles between each of those directions and a vector normal to the local surface gradient, respectively, gave the CTX-derived local incidence and emergence angles (Fig. 4).

An additional useful result is the identification of surfaces where the incidence or emergence angle (or both) is greater than 90° for a given CRISM observation. These high values mean that a given surface is either shadowed or tilted away from MRO at such a high angle that it is entirely unobserved. Any pixels in a CRISM observation where one of these orientations occurs cannot be used to provide a valid SKT or SSA value. These features can only be identified through spatial data at this resolution; MOLA topography is too coarse to identify hidden pixels in the scenes tested.

Work is proceeding on incorporation of CTX-derived local angles into our pipeline. Initial back projection into sensor space and use in processing are encouraging in that much more stratigraphic and mineralogic detail is evident, particularly for the sulfate section. In addition, finer details are evident in retrieval of SKT values, longer wavelength SSA values, and 3 µm hydration absorption patterns.

References: [1] Kreisch C. D. et al. (2017) *Icarus, 282*, 136-151. [2] Politte D. V. et al. (2018) *LPS XLIX*, Abstract #2063. [3] Politte D. V. et al. (2019) *LPS L*, Abstract #2690. [4] Murchie S. et al. (2007) *JGR: Planets*, *112* (E5). [5] Hapke B. (2011) *Theory of Reflectance and Emittance Spectroscopy*. [6] He L. et al. (2019) *LPS L*, Abstract #2094. [7] Fraeman, A. A. (2016) *JGR.: Planets*, *121*, 1713-1736. [8] Fox V. K. et al. (2019), these abstracts. [9] Fornberg, B. (1988) *Mathematics of Computation*, *51*, 699-706. [10] Viviano-Beck et al. (2014) *JGR: Planets*, *119*, 1403-1431.

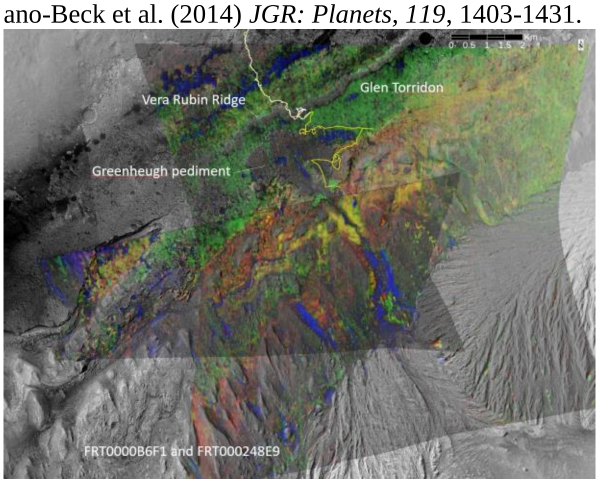

Figure 1: The color coding uses RGB as SINDEX2, 1.9 µm hydration, and high calcium pyroxene, respectively, from [10]. Blue areas based on comparison with HiRISE and Curiosity data correspond to modern wind-blown basaltic sands. The green areas contain hydrated phases. The yellow areas correspond to polyhydrated sulfate-bearing strata. The red areas, on the other hand, do not have a significant 1.9 µm hydration absorption, and examination of spectra show the presence of a 2.1 µm absorption indicative of the presence of one or more mono-hydrated mineral(s) such as kieserite. White line shows Curiosity's traverse and yellow line shows the MSAR-8 planned extended mission traverse. The smaller frame is the ATO and parameter maps are shown overlain onto a HiRISE-based mosaic.

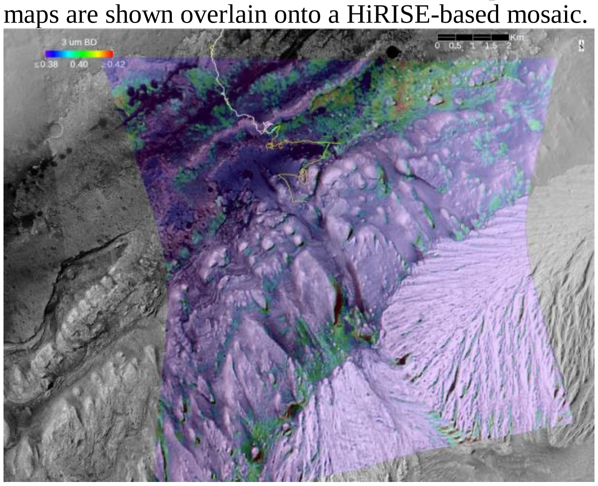

Figure 2: Retrieved 3 µm integrated band depths are shown for FRT0000B6F1 and indicate enhanced hydration in Glen Torridon and selected areas in other regions. Vera Rubin Ridge and Greenheugh pediment do not show high values.

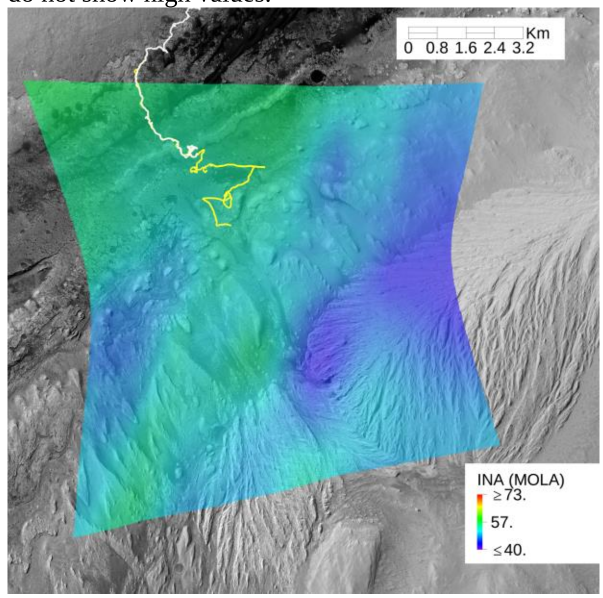

Figure 3: Incidence angles (INA) in degrees derived from smoothed MOLA topography over Gale Crater for CRISM scene FRT0000B6F1 over a HiRISE mosaic. Illumination is from the west (~303° clockwise from north) at ~32° above the local horizon; sun-facing slopes have low incidence angles.

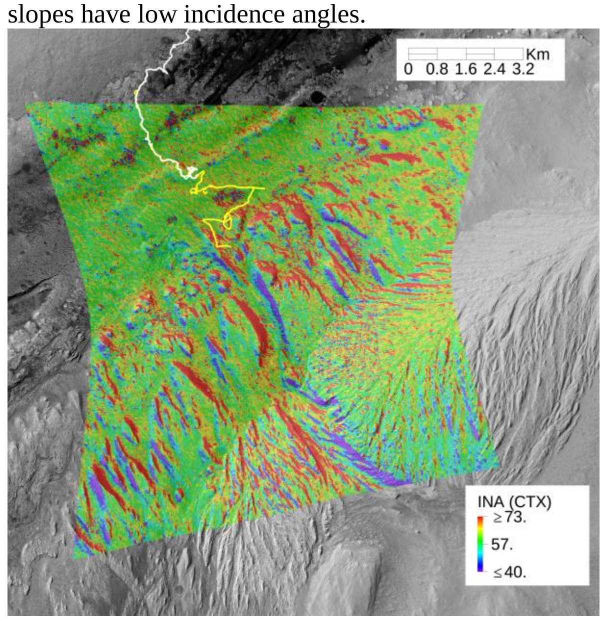

Figure 4: Incidence angles (INA) derived from the CTX DEM over Gale Crater for CRISM scene FRT0000B6F1, using the same color scale as Figure 1. CTX-derived incidence angles provide much more detail as compared to angles derived MOLA data.