HIRISE ANALYSIS OF THE WESTERN RIM OF ENDEAVOUR CRATER, MERIDIANI PLANUM, MARS: MORPHOLOGY, COMPOSITION AND TOPOGRAPHY.

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Introduction and Motivation: The Mars Exploration Rover Opportunity [1] is currently *en route* to investigate the ~20−km−diameter Endeavour crater in Meridiani Planum [2]. This crater is a high value target due, in part, to the remotely-sensed composition of the western crater rim, which includes aqueous altered minerals proposed to be Noachian in age [3]. Here we have performed compositional and topographic analyses of the western Endeavour crater region (2.1°-2.5°S, 5.4-5.3°W) where Opportunity is anticipated to begin its *in situ* analysis. Specifically we have investigated Capes York, Tribulation, and Byron (Fig. 1) [2].

Our motivating questions are: What is the horizontal and vertical extent of aqueous alteration at Endeavour crater? Where are the compositions exposed and are they accessible to Opportunity? How do HiRISE band ratios correlate with CRISM-detected mineralogy? Moreover, our goal is to examine possible geologic contacts Opportunity might visit to test the hypothesis that rim units predate regional layered deposits and formed in different environmental conditions.

Background: Using CRISM spectra, *Wray et al.* [3] first identified phyllosilicates (Fe/Mg-smectite clay) in the crater rim and polyhydrated sulfate in the surrounding plains (Fig. 1). More recently, hydration (consistent with sulfates) was also detected on the crater floor [4] based on the 1.94-μm absorption of water-bearing minerals. These spectral signatures have not yet been investigated *in situ* anywhere on the surface of Mars.

Methods: Crater morphology is examined to provide geologic context for surface composition. For this task, we used image data from MRO's HiRISE instrument at 25 cm/pix [5]. Near-infrared reflectance spectra from CRISM [6] were employed for surface composition. In coordination with CRISM-mapped mineralogy, we used HiRISE multi-band color images (IR at 0.88 μm, RED at 0.69 μm, and BG at 0.50 μm) to assess meter-scale changes in color and inferred composition over a limited portion of the spectrum [7]. The three bands were independently scaled to I/F space, shadowed areas subtracted (offset), and band ratios created as discussed in [7]. This technique removes most atmospheric and topographic contributions so color variations are related to surface composition. In general, it allows one to distinguish between terrains bearing mafic vs. altered mineralogy due to the relative absorption features of ferrous vs. ferric iron at HiRISE band positions. HiRISE stereo coverage was used to construct a DEM using SOCET SET® BAE system photogrammetry software at the USGS processing guest facility [8], by the method outlined in [9]. The resulting DEM of Endeavour crater's western rim has ~1 m/pix horizontal and <1 m vertical precision that will aid in the strategic planning of the Opportunity rover.

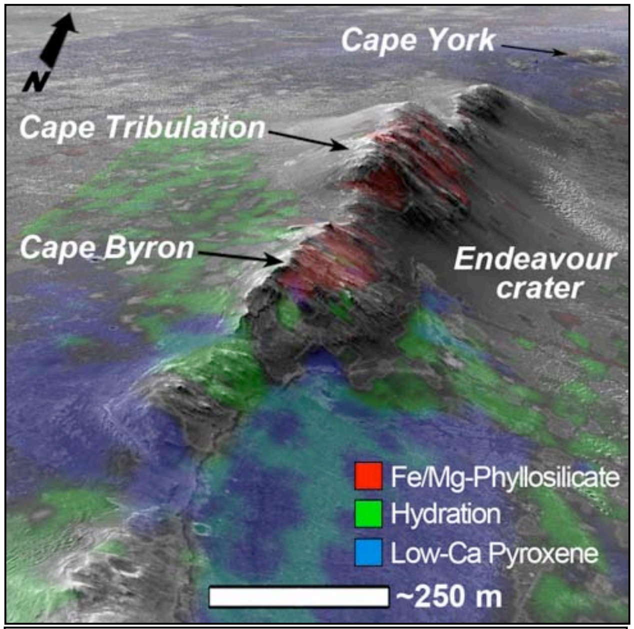

Figure 1. HiRISE (ESP_018846_1775) and CRISM mineralogy (FRT0000CE1D (N), and FRT00008541 (S)) laid over a HiRISE DEM showing Endeavour crater's western rim. CRISM spectral indices are D2300 (red), BD1900H (green), and LCPINDEX (blue) as defined by [10,11]. Note: some smoothing occurred with data re-projection. As of 1/2011, *Opportunity* is ~9 km to the NW.

***Cape York*:** Closest to Opportunity's present (1/2011) position is the small (~800 m by ~220 m) rim promontory of Cape York (Fig. 2). Bedrock exposures are found at the base and summit with discontinuous detrital material covering the intermediate slopes. Hummocky, fractured summit material crops out above a coherent and uniform base layer that is ~20 m wide and ~1-3 m thick. Initial CRISM observations [3] revealed several pixels of Fe/Mg-phyllosilicates centered on the rim (Fig. 2). These and other adjacent locations display HiRISE color band ratios consistent with ferric minerals (*i.e.,* high IR/RED and IR/BG ratios) also shown in Fig. 2.

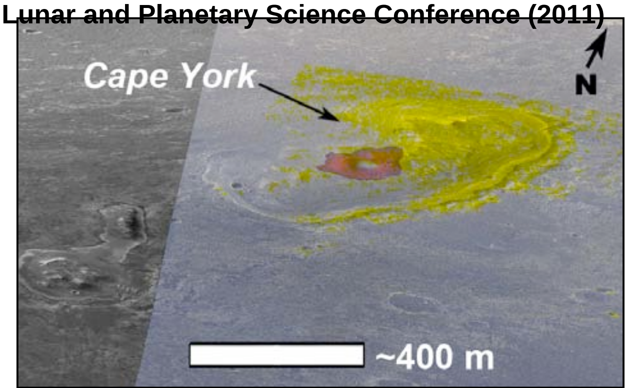

Figure 2. An oblique HiRISE view of Cape York. CRISM-detected phyllosilicate material is shown in red and arbitrary threshold HiRISE band ratio values (IR/RED and BG/RED) consistent with ferric minerals in orange.

The Cape York promontory shows ~7 m of relief and slopes inward (SE) at a ~7° slope. This orientation could be advantageous as the western portion of the rim is relatively flat lying (~3.6°). CRISM-detected hydrated surfaces surround this cape and are found on the westward side at ~3° slopes. The close proximity of hydrated phases that appear to be onlapping older phyllosilicate-bearing crustal material, all on relatively muted topography, make these geologic contacts a tempting drive target for Opportunity.

***Cape Tribulation*:** The tallest portion of the crater rim, Cape Tribulation (~85 m above the adjacent plains), is also associated with the largest CRISM-identified phyllosilicate exposure in the area, primarily found eastward of the summit (Fig. 1). This summit is also distinct in HiRISE color data, where band ratios correlate well with CRISM detections of phyllosilicates and hydrated minerals (Fig. 3).

Cape Tribulation has large average and maximum slopes. However, one phyllosilicate-bearing outcrop, located on the northwestern portion of the rim (Fig. 3) and possessing an average slope of ~7°, may be accessible to Opportunity. Unfortunately, HiRISE color coverage of Cape Tribulation's (and Byron's) western slopes is not available for band ratio analysis to determine the extent of ferric-bearing surfaces.

***Cape Byron*:** Cape Byron (~40 m above the adjacent plains) also has large exposures containing clay minerals. The majority of these detections are found on the eastern portion of the crater rim. Also, large exposures of finely layered hydrated phases (Fig. 3) are present just below the inside rim (~100 m below the plains). Sedimentary units, previously identified to contain polyhydrated sulfates [3], are distinct in HiRISE band ratioed images (Fig. 3) and plots (not shown). With high average slope values on the altered mineral surfaces, Cape Byron does not appear to have the most accessible sedimentary units for *in situ* study.

Summary & Future Direction: Portions of all three capes have similar HiRISE band ratios indicative of altered minerals containing ferric iron. These observations are consistent with CRISM spectra and, in the case of Cape York, suggest greater spatial extent

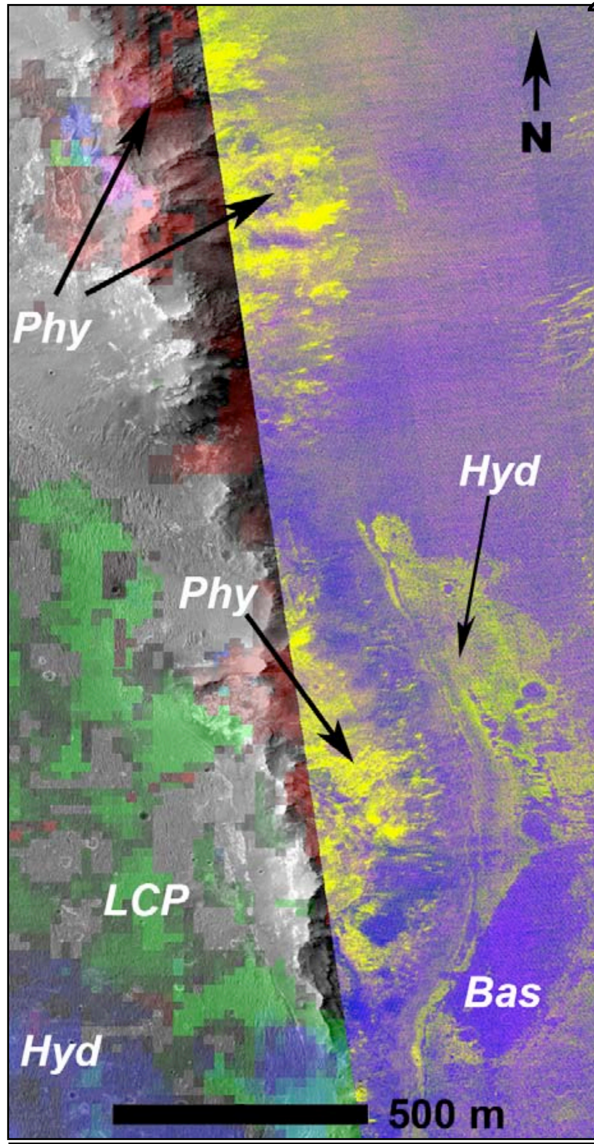

Figure 3. Cape Tribulation (top) and Byron (bottom). On the left a HiRISE grayscale image with CRISM mineralogy overlaid (same color convention as Fig. 1). On the right a HiRISE I/F band ratio image where red is IR/RED, green is IR/BG, and blue is BG/RED. Mineral phases are: phyllosilicates (Phy), hydrated surfaces (Hyd), basaltic material (Bas), and are yellow, orange, and purple, respectively, in the band ratio image.

of these phases. On going CRISM [12] and color HiRISE analysis will be needed to fully maximize the scientific yield from Opportunity's upcoming exploration of Endeavour crater.

References: [1] Squyres S. W. et al. (2004) *Science, 306*, 1709–1714. [2] Arvidson R. E. et al. (2011) *JGR, 116*, doi:10.1029/2010JE003746. [3] Wray J. J. et al. (2009) *GRL, 36,* L21201. [4] Chojnacki M. et al. (2010) *LPS XXXXI,* #2175. [5] McEwen A. S. et al. (2007) JGR, 112, E05S02. [6] Murchie S. et al. (2007) JGR, 112, E05S03. [7] Delamere W. A. et al. (2010) *Icarus, 205*, 38 - 52. [8] Kirk R. L. et al. (2009) *LPS XXXX*, #1414. [9] Kirk R. L. et al. (2008) *JGR, 113*, E00A24. [10] Pelkey S. M. et al. (2007) *JGR, 112*, E08S14. [11] Ehlmann B. L. et al. (2009) *JGR, 114*, E00D08. [12] Fraeman, A. (2011) this conference volume.