ASSESSING THE MINERALOGY OF ACIDALIA PLANITIA, MARS, USING NEAR-INFRARED ORBITAL SPECTROSCOPY.

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Introduction: The northern lowlands of Mars in the Acidalia region [1] have been interpreted as vast expanses of ridged plains produced by Hesperian lavas [2] superimposed by outflow channel sediments [3, 4] and subsequently modified by latitude-dependent processes [5]. Regional studies using TES [6], OMEGA [7], and GRS [8] datasets are consistent with basaltic compositions with limited amounts of surface alteration. High resolution data from the HiRISE [9] and CRISM [10] instruments on the MRO spacecraft provide new opportunities to understand the evolution of this region by examining the compositional stratigraphy exposed by impact craters. Here we focus on constraining the stratigraphy and mineralogy exposed in impact craters at high spatial resolution (tens of meters).

Regional Observations Using OMEGA: Acidalia Planitita is dominated by a spectral blue slope in the near-infrared (NIR) [7], which is defined as a decrease in reflectance between 1 µm and 2.5 µm. Our analysis calculates the strength of the blue slope as the difference between reflectances at 1 µm and 2.5 µm normalized by the reflectance at 1 µm. Spatial variabilities were identified in the observed blue slope, most notably leeward of impact craters. Mafic absorptions in regions with a strong blue slope are weak to absent [11]. Aerosol and atmospheric effects that do not reflect surface variations are also observed.

CRISM Methods: CRISM data are initially investigated using spectral parameters [12] and positive mineral identifications are validated by detailed spectral analyses. High-calcium pyroxene (HCP) is detected by the HCP CRISM parameter [12]. The olivine parameter (OLINDEX [12]) measures olivine's 1 µm absorption feature based on a horizontal line measured from 1.7 µm. However, OLINDEX falsely identifies olivine in regions with a strong NIR blue spectral slope or high albedo. OLINDEX_2 was thus created to better identify the 1 µm olivine absorption feature. The OLINDEX_2 parameter fits a trend to the spectra of each pixel between 1.75 µm and 2.4 µm and measures the depth of olivine's 1 µm absorption feature from the modeled trend using the OLINDEX formula [12]. This modification better models the shape of the spectra to account for variations in spectral slope.

CRISM Results: All targeted CRISM images in Acidalia Planitia and into Chryse Planitia obtained between the start of the primary mission and September 6, 2008 were examined. Of the 113 good quality images (no contamination from aerosols or extensive water ice), 80.5% show distinct mafic signatures, primarily olivine and HCP. The updated OLINDEX_2 parameter reveals widespread, *in situ* olivine-bearing units at or near the surface throughout much of Acidalia Planitia. Olivine was confirmed spectrally by its broad 1 µm absorption feature and lack of 2 µm absorption feature. HCP is most often seen in association with strong olivine absorptions, although a few occurrences of only HCP do exist. HCP was confirmed spectrally by the presence of both 1 µm and 2 µm absorption features. With a few exceptions along the dichotomy boundary (most notably Mawrth Vallis), Acidalia Planitia lacks distinct hydrated alteration products like sulfates or phyllosilicates.

41 images between 19° N and 64° N show olivine associated with the ejecta, *in situ* floor material, interior walls or distinct layers in the walls of the impact craters. With increasing latitude, the presence of olivine appears more subdued and the geologic contacts between olivine-bearing units and those not containing olivine become more muted and diffuse (Fig. 1).

To better understand the geologic context of these units, we use HiRISE color imagery in conjunction with CRISM observations. Olivine enrichments appear

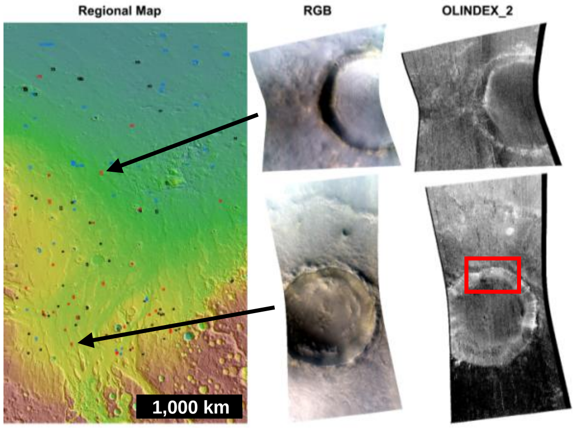

Fig. 1. An illustration of the decreasing frequency of olivine detections and the more muted appearance of olivine with increasing latitude. Red outlines show mafic signatures, black outlines lack mafic signatures, and blue outlines are poor quality observations or are contaminated with excessive water ice. RGB color (R = 2.38 µm, G = 1.80 µm, B = 1.15 µm) and OLINDEX_2 maps of CRISM images FRT00003CE7 (top) and HRL00006247 (bottom). The red outline in the OLINDEX_2 map of HRL00006247 is shown in Fig. 2.

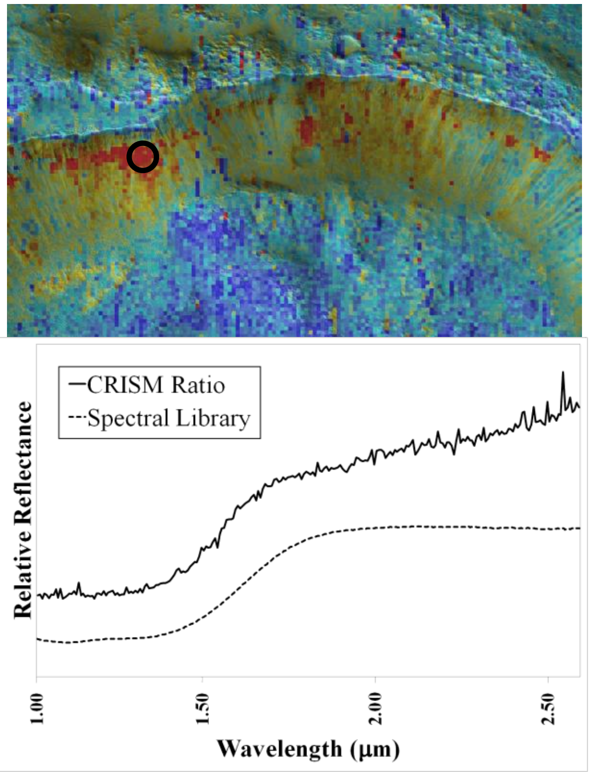

Fig. 2. (Top) HiRISE image PSP_004066_2010 with the OLINDEX_2 values for CRISM image HRL00006247 superimposed. A strong olivine absorption can be seen in the subsurface bedrock layer and talus slopes (red). (Bottom) 5x5 pixel average spectral ratio for the region circled in black along with a laboratory fayalite spectra. The positive slope observed in the CRISM ratioed spectra beyond 1.7 µm is due to performing the ratio with a blue-sloped denominator spectrum.

bright blue in the standard IR-RED-BG combinations. These observations confirm that olivine enrichments are associated primarily with near-surface bedrock outcrops and talus slopes originating from outcrops, especially in Chryse and southern Acidalia planitiae (Fig. 2). Crater ejecta also exhibit varying degrees of olivine enrichment (Fig. 1).

Olivine enrichment is also observed within many impact craters in central and northern Acidalia Planitia. These craters lack distinct olivine enriched layers and talus slopes and instead exhibit more diffuse olivine-enriched regions and shallower olivine absorptions. Relatively weaker absorptions and an overall muted appearance indicate that olivine may be less abundant in these outcrops than in those observed in southern Acidalia and Chryse planitiae or that the olivine may be obscured by alteration products. These diminished spectral signatures may also indicate an increase in surface processes such as cryoturbation or thicker latitude-dependent mantling units.

Implications and Conclusions: The presence of distinct olivine rich layers at or near the surface of Acidalia Planitia is consistent with a primarily basaltic composition for the volume of the plains units. The majority of the uncratered surface, however, exhibits a strong NIR blue slope with a lack of distinct mafic features, which is consistent with alteration or coatings [13].

The decrease in the strength of olivine's 1 µm absorption feature and the change in appearance and context with increasing latitude suggest that permafrost-related processes may be modifying or reworking the olivine-bearing units at higher latitudes. This transition roughly coincides with the Vastitas Borealis Formation (VBF) boundary. The VBF has been thought to be a mixture of sediments that has been extensively altered by cryoturbation and other processes common in terrestrial permafrost environments [1]. South of the VBF, these permafrost-related processes are much less prevalent and thus the presence and strength of the observed olivine absorptions are stronger and more distinct. Further north into the VBF, olivine is still present although its appearance is more muted and its geologic setting is less certain, likely due to subsequent modification, sediment deposition, and permafrost-related processes.

Using CRISM to assess the history of Acidalia Planitia allows us to determine geologic context and relationships that were previously beyond the resolution of other instruments. Future work will be performed to quantitatively constrain the thickness of the surficial layer and the depth to the olivine-bearing units to assess spatial variations in the depth and degree of alteration in Acidalia Planitia.

References: [1] Tanaka K. L. et al. (2003) *JGR, 108,* doi:10.1029/2002JE001908. [2] Head J. W. et al. (2002) *JGR, 107*, doi:10.1029/2000JE001445. [3] Tanaka K. L. (1997) *JGR, 102,* 4131-4150. [4] Kreslavsky M. A. and Head J. W. (2002) *JGR, 107,* doi:10.1029/2001JE001831. [5] Head J. W. et al. (2003) *Nature, 426*, 797-802. [6] Wyatt M. B. et al. (2004) *Geology, 32*, 645-648. [7] Mustard J. F. et al. (2005) *Science, 307*, 1594-1597. [8] Karunatillake S. et al. (2006) *JGR*, *111*, doi:10.1029/2006JE002675. [9] McEwen A. S. et al. (2007) *JGR, 112,* doi:10.1029/2005JE002605. [10] Murchie S. et al. (2007) *JGR, 112*, doi:10.1029/2006JE002682. [11] Poulet F. et al (2007) *JGR, 112,* doi:10.1029/2006JE002840. [12] Pelkey S. M. et al. (2007) *JGR, 112,* doi:10.1029/2006JE002831. [13] Wyatt M. B. and McSween H. Y. (2002) *Nature, 417*, 263-266.