EXTENDING CRISM SPECTRAL COVERAGE IN GALE CRATER USING THEMIS-VIS AND HIRISE.

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Introduction: The landing site for the Mars Science Laboratory (MSL) "Curiosity" rover is Gale Crater, a ~150 km impact crater near 5°S, 222°W along the north-south dichotomy boundary. Gale was selected partly because of its 5 km high central mound of sedimentary rocks that has been shown to contain both phyllosilicates and sulfates, which could have implications for past large-scale climate changes on Mars [1-4]. The Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) instrument on the Mars Reconnaissance Orbiter (MRO) was used to identify these phyllosilicate and sulfate layers [2]. In this study, we investigate whether MRO's High Resolution Imaging Science Experiment color images (HiRISE color) and the Mars Odyssey orbiter's Thermal Emission Imaging System visual images (THEMIS-VIS) can be used to identify clay and/or sulfate deposits at finer spatial scales and/or in areas not yet measured by CRISM within Gale Crater and elsewhere.

Data Sets: Narrowband multispectral filters for 36 m/pix THEMIS-VIS color data sets are centered at 425, 540, 654, and 749 nm [5] and broader filters for HiRISE 25 cm/pix color data are at 500, 700, and 900 nm [6]. These bands are within CRISM's spectral range, which reaches from 362 to 3920 nm [7].

One motivation for this study stems from the higher spatial coverage of the THEMIS-VIS dataset in Gale Crater compared to CRISM (~half of Gale Crater now covered in THEMIS-VIS, with full coverage expected before the August 2012 MSL landing, compared to ~30% covered by 18 and 36 m/pixel CRISM), and the high resolution (~25 cm/pix) and moderate coverage within Gale of the HiRISE color dataset compared to CRISM spatial resolution (18-72 m/pix). Thus, THEMIS-VIS color data could potentially be useful in extending CRISM compositional interpretations over more of the crater and MSL field site, and HiRISE color data could potentially be used to identify important compositional units and contacts at higher spatial resolution.

Methods: HiRISE color data have been used to qualitatively identify layers of clays and sulfates identified by CRISM [8,9]. Some of these minerals, especially iron-bearing ones like those potentially identified in this region and elsewhere, also exhibit potentially-detectable spectral slope or absorption band variations at visible to short-wave near-IR wavelengths [*e.g.,* 10]. Thus, we are examining HiRISE and THEMIS-VIS 3- or 4-color "spectra" of different regions within Gale crater that have been compositionally identified by CRISM, in an attempt to identify potentially quantitative spectral parameters that might correlate with CRISM clay detections. Examples of initial simple parameters being investigated include the red/blue color ratio and visible spectral curvature. This pilot study is focusing on a clay/sulfate contact in the so-called "grand canyon" that cuts deeply into the western margin of Gale Crater's central mound [2].

Table 1. THEMIS-VIS band-integrated solar spectral irradiances at 1 AU.

Filter (nm)	πF (W cm^{-2} μm^{-1})
425	0.1714
540	0.1860
654	0.1547
749	0.1261

First we converted the PDS-archived THEMIS-VIS and HiRISE radiance data to radiance factor (*I/F*, where *I* is the measured radiance on sensor, and πF is the solar spectral irradiance [11] at the top of the Martian atmosphere at the time of the observation), and then to estimated Lambert albedo by dividing the *I/F* data by the cosine of the average solar incidence angle within the scene of interest. Table 1 provides the relevant solar spectral irradiance data convolved over each filter's bandpass [5] required for these THEMIS-VIS conversions. HiRISE data can be converted to *I/F* using information and keywords provided in each data file's image label.

Preliminary Results: CRISM data have been interpreted to show that a light-toned layer exposed in the walls of the large canyon in Gale's mound contains phyllosilicate clays (possibly mixed with sulfates), while the surrounding beds have spectra consistent with only sulfates [2]. Figure 1 shows THEMIS-VIS and HiRISE color data of this light-toned layer. HiRISE data reveal that the light-toned clay-bearing unit can be further resolved into finer layers of lighter- and darker-toned materials, with the darker-toned materials exhibiting colors similar to the layers surrounding the clay-bearing materials.

THEMIS-VIS and HiRISE spectra of the clay-bearing and surrounding units within the Gale canyon are very similar (Figs. 1b, 1d). To attempt to identify a spectral parameter that could potentially differentiate between clay-bearing and non-clay-bearing units (as detected by CRISM), we analyzed the HiRISE 900 to 700 nm color ratio of these materials (Figure 2). The clay-bearing unit ("Dark Purple") exhibits a higher 900/700 nm value than the other selected units, and the ratio is higher than the average ratio of the entire image. The darker-toned layer just below the light-toned layer ("Teal") also exhibits a slightly higher ratio value

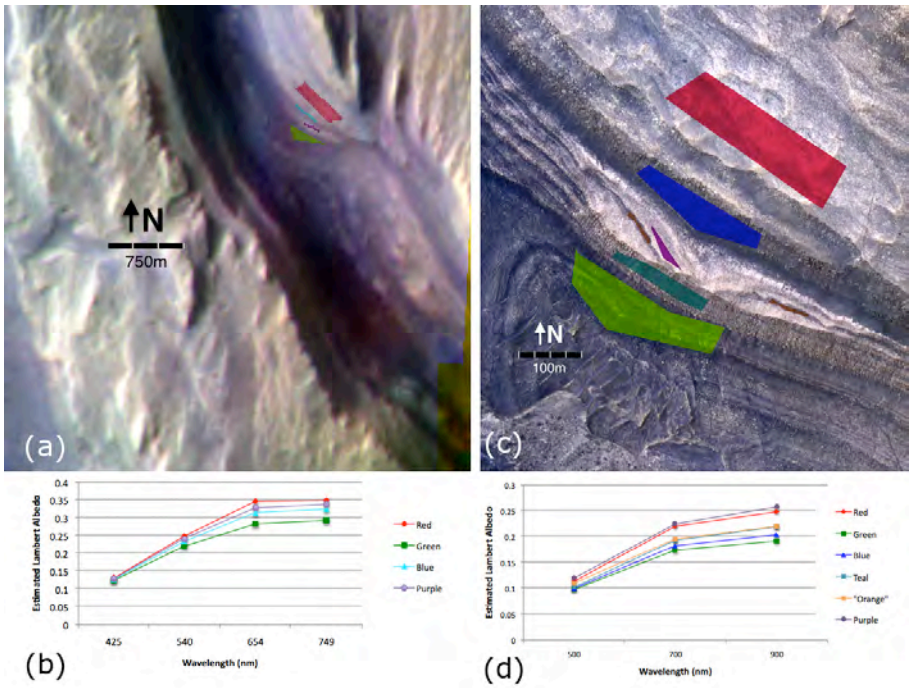

Figure 1: (a) THEMIS-VIS color composite from part of image V19628010 (36 m/pix) within the "Grand Canyon" of Gale crater, using bands 749, 654, and 540 nm as RGB. The red selection samples the layer interpreted from CRISM data as a clay-bearing unit [2]. (b) THEMIS-VIS 4-color "spectra" of the selected regions in (a). (c) Portion of HiRISE color image PSP_006855_1750_COLOR (25 cm/pix) composited using bands 900, 700, 500 nm as RGB. The purple selection region in the light-toned layer is the clay-bearing unit [2]. (d) HiRISE 3-color "spectra" of the selected regions in (c).

than other units, possibly because mass wasting processes could be transporting material from the clay-bearing layer downslope to mix with non-clay-bearing materials. Alternately, this could also be a clay-bearing unit but discriminating it is below the limit of CRISM spatial resolution. Our initial spectral analysis of 4-band THEMIS-VIS color data within Gale crater has not yet identified a specific color ratio or other spectral parameter that exhibits a strong correlation to regions where CRISM has detected clays.

Future Work: This pilot study is helping us develop ways to compare THEMIS-VIS and HiRISE images that overlap with CRISM coverage, thus potentially extending compositional inferences to nearby regions that lack CRISM coverage. We are exploring different band ratios and other spectral parameters to assess their level of correlation with CRISM-derived mineral detections, with the intention of quantifying what have mostly to date been rather qualitative comcomparisons among visible wavelength color data sets and near-IR hyperspectral images.

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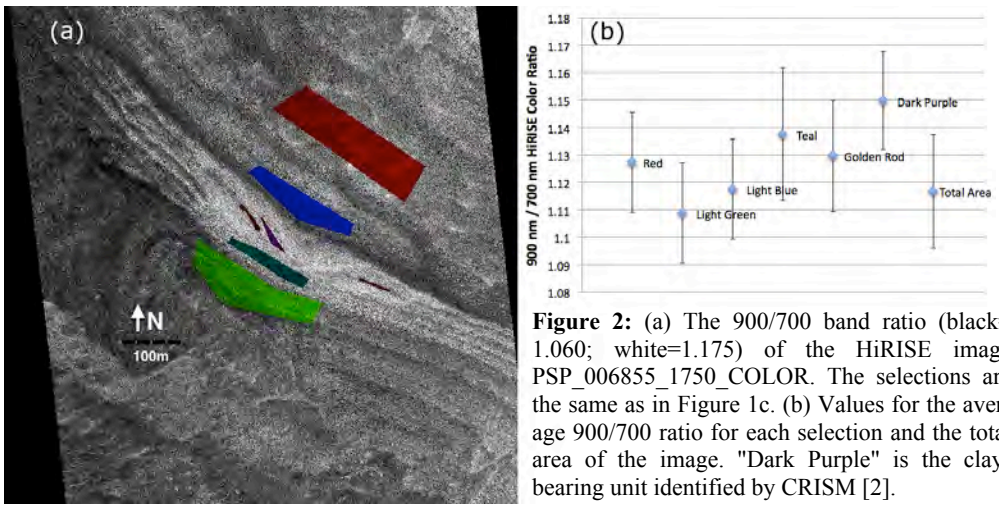

Figure 2: (a) The 900/700 band ratio (black= 1.060; white=1.175) of the HiRISE image PSP_006855_1750_COLOR. The selections are the same as in Figure 1c. (b) Values for the average 900/700 ratio for each selection and the total area of the image. "Dark Purple" is the clay-bearing unit identified by CRISM [2].