THE GEOLOGIC CONTEXT OF HEMATITE IN VALLES MARINERIS: COMPARISON OF CRISM DATA TO RESULTS FROM TES, THEMIS AND OMEGA.

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Introduction: Concentrations of coarsely-crystalline grey hematite have been identified by the Mars Global Surveyor Thermal Emission Spectrometer (TES) in three regions of Mars within 15° of the equator: Meridiani Planum, chaotic terrain near Ares Valles, and in Valles Marineris [*1, 2*]. Light toned, layered, sulfate-bearing deposits detected by Mars Express hyperspectral visible/near-infrared imager, Observatoire pour la Minéralogie, l'Eau, les Glaces, et l'Activité (OMEGA) [*3*], are found in close association with hematite in all three areas. In other areas, extensive sulfate deposits have been identified without associated hematite [*4*] indicating that hematite formation within sulfate bearing deposits involves conditions that were not present everywhere on Mars. Hypotheses surrounding the formation of hematite commonly involve persistent liquid water e.g. [*1, 5-8*]. Hematite may be an indicator of previously wet environments on Mars.

The purpose of this study is to further investigate the geologic and mineralogic context of hematite concentrations and the associated sulfate bearing layered materials. Results obtained from spectral analysis of TES, Mars Odyssey Thermal Emission Imaging Spectrometer (THEMIS) [*9*], and OMEGA [*10, 11*] data are compared with newly acquired data from Mars Reconnaissance Orbiter Compact Reconnaissance Imaging Spectrometer for Mars (CRISM). The thermal infrared instruments (TES, THEMIS) are sensitive to molecular vibrations and these datasets are ideally suited for characterization of silicates and oxides. Visible to near infrared instruments (CRISM, OMEGA) are sensitive to molecular vibrations associated with hydrated materials and electronic features associated with transition metal bearing phases. With the thermal infrared providing bulk mineralogy and the VIS/IR identifying hydrated and iron-bearing phases, these datasets provide synergistic mineralogic context for the hematite deposits in Valles Marineris.

Methods: The CRISM instrument has the capability to map at a full resolution of ~15 to 19 m/pixel in 544 visible to infrared channels from 0.362 to 3.92 µm [*12*]. OMEGA collects 352 spectral channels from 0.35 to 5.1µm and has a spatial sampling that ranges from 300 m to 4800 m [*4*]. The thermal infrared datasets of TES [*13*] and THEMIS [*14*] have spatial resolution of ~3x8 km, and 100 m respectively, and spectral coverage from 6 to 50 µm in 143 bands and from 8 to 15 µm in 9 unique bands.

CRISM data have been processed to cosine-corrected I/F. An empirical atmospheric correction has been performed using an elevation-scaled atmospheric transmission spectrum derived from observations at the base and top of Olympus Mons, after methods used by the OMEGA team [*4*]. Spectrally interesting areas were identified using band parameter maps [*15*]. Relative spectra were obtained by differencing data of interest with spectrally bland regions of similar albedo in the same data column. Further work will incorporate atmospheric correction using radiative transfer techniques to provide spectra that are directly comparable to laboratory standards.

Geologic context from TES, THEMIS and OMEGA: Hematite and associated materials have been mapped in Valles Marineris using thermal infrared spectral data from TES and THEMIS with complementary data from the Mars Orbiter Laser Altimeter (MOLA) and high resolution images from the Mars Orbiter Camera (MOC) [*9*].

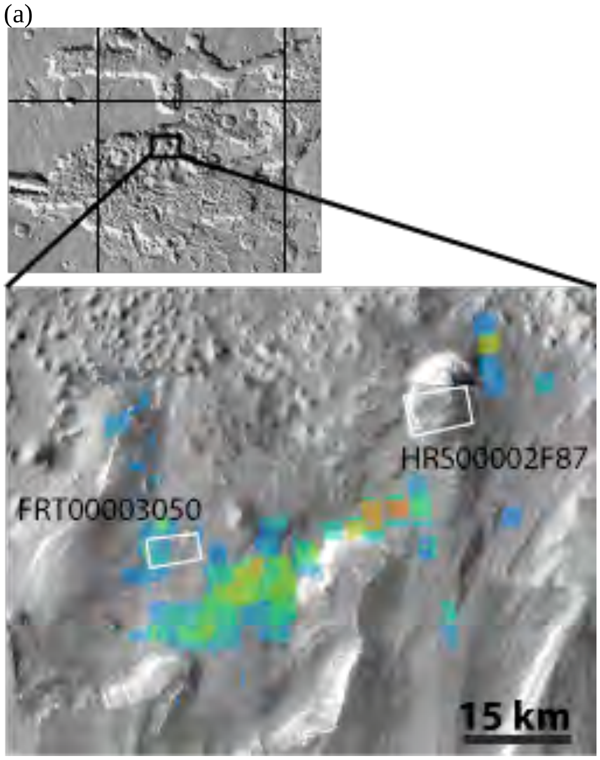
Hematite in Ophir and Candor Chasmata is generally located down-slope from the layered materials from which it is likely derived. This is likely a density driven separation resulting in lag deposits commonly located in topographic lows, or at benches in slopes. Hematite-rich areas exhibit smooth, low albedo surfaces with few visible bedforms.

In Capri and Melas Chasmata, the hematite forms similar smooth, low albedo deposits, but instead of lag deposits collecting down slope from layered materials, it occurs on in-place layered materials situated near the base of the interior layered deposits. The hematite is often associated with positive relief features such as knobs or ridges, and may form a resistant cover that protects layers beneath from further erosion. Hematite may be concentrated in a stratigraphic horizon.

Composition: Materials intermixed with hematite throughout the Valles Marineris system are primarily basaltic in nature. Linear deconvolution [*16*] of TES data indicate that they consist of: 30-45% pyroxene, 15-20% plagioclase, 5-10% olivine, 5-20% glass or phyllosilicates, and 5-25% sulfates. Hematite-rich areas and surrounding surfaces without measurable hematite are spectrally indistinguishable in THEMIS data, with a consistently basaltic shape [*9*].

OMEGA data indicate that interior layered deposits in Candor Chasma contain both a polyhydrated sulfate and a monohydrated sulfate, identified as kieserite [*3*, *10*]. Kieserite is preferentially associated with steeper slopes in West Candor Chasma and is likely to be a freshly exposed component of the interior layered deposit layers. Polyhydrated sulfates are found throughout sulfate-rich areas, and may have interacted with atmospheric water [*17*].

(a)



(b)

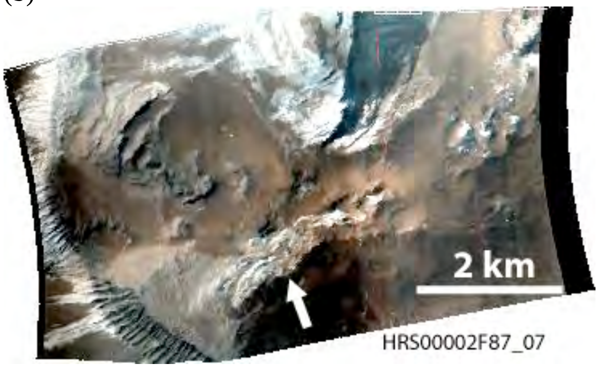


Fig 1. (a) Context of the CRISM frames in Capri Chasma, eastern Valles Marineris on THEMIS mosaic. Boxes are approximate footprints of images and colors represent hematite concentration from TES. (b) CRISM false color IR image (R, G, and B are 2.528, 1.505, and 1.0784 μm respectively) of the top of a knob that is an outlier of the interior layered deposit material. Steep slopes (e.g. arrow) show spectral evidence for polyhydrated sulfates.

Preliminary CRISM Results: Two images acquired in the Capri Chasma region of Valles Marineris near concentrations of hematite have been examined (Fig. 1). CRISM image HRS00002F87_07 covers an area with interior layered deposit material that lies to the southwest of a hematite concentration mapped with TES data. Spectral analysis indicates that polyhydrated sulfate is likely present in the steepest slopes within the interior layered deposit. A monohydrated sulfate such as kieserite may be present on less steep slopes. The variation in sulfate hydration with slope may indicate active phase change or that the presence of the specific mineral signature is associated with the degree of induration and thus resistance to weathering of the particular bedrock unit. The relationships between these materials are under investigation.

Image FRT00003050_07 covers an area where hematite is concentrated near the base of interior layered deposits, superposed on the chaotic terrain of the canyon floor. Spectra are generally bland, showing little to no hydration features and are generally consistent with predominantly basaltic materials.

Discussion: Preliminary results indicate that CRISM spectral data are consistent with previous analyses from TES, THEMIS, and OMEGA and reveal fine details of the relationships between mineral phases that are below the spatial resolution of previous datasets. Further analysis of CRISM data are expected to provide insight into the relationships between the different sulfates associated with hematite, the nature of correlation of hematite with the sulfates, and the correlations of the sulfate bearing materials to the predominantly basaltic material surrounding the hematite, allowing further examination of the genetic relationship between the hematite and the sulfate-bearing layered materials and the history of water in Valles Marineris.

References:

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