

NEW HYDRATED PHASE DETECTIONS IN VALLES MARINERIS: INSIGHTS INTO THE CANYON'S AQUEOUS HISTORY. J. Flahaut¹, J. L. Bishop², F. Fueten³, C. Quantin⁴, P. Tholot⁴, W. van Westrenen¹ and G.R. Davies¹. ¹Faculty of Earth and Life Science, VU University Amsterdam, de Boelelaan 1085, 1081HV Amsterdam, The Netherlands (jessica.flahaut@ens-lyon.org). ²SETI Institute/NASA-ARC, Mountain View, CA, 94043 ³Department of Earth Sciences, Brock University, St. Catharines, Ontario, Canada. ⁴Laboratoire de Géologie de Lyon (LGL-TPE), CNRS/Université Lyon 1, 69622 Villeurbanne Cedex, France.

Abstract: This paper presents a survey of the mineralogical diversity of the Interior Layered Deposits (ILDs) of Valles Marineris (VM) and Margaritifer Terra (MT) as seen with the high-resolution hyperspectral imager CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) onboard MRO (Mars Reconnaissance Orbiter). A particular emphasis is made on localized detections of new hydrated phases within the dominant sulfate-rich deposits. Characterizing the entire mineral assemblages should provide more information on the chemistry of those deposits and their potential formation mechanism(s).

Introduction: Sulfates have been detected in association with the kilometer-thick ILDs of Valles Marineris [1-4]. These detections, made by the imaging spectrometer OMEGA in 2004, appear to be stratigraphically distributed [3,5]. Mg-rich monohydrated sulfates (MHS) have been observed at low elevations whereas polyhydrated sulfates (PHS) seem more commonly detected in the topmost part of these deposits. MHS and PHS are identified in the visible near-infrared domain from their coupled absorptions at 2.1 and 2.4 μm , and 1.9 and 2.4 μm respectively [1,2]. They are often detected together with ferric oxides [5-8]. These observations, coupled with evidence for a major stratigraphic discontinuity, led Fueten et al. [9] to propose a two-stage history for the formation of the ILDs of Candor Chasma, a subset of central Valles Marineris. The two units forming the ILDs could have different origins, such as: lacustrine deposits [10-13], erosional waste of the canyon walls [13], sub-ice volcanic structure [14-15], non-aqueous aeolian or volcanic deposits [16]. To date there is still no consensus on the formation mechanism and potential origin of the ILDs.

A wealth of spectral data at higher spatial resolution from CRISM is now available to focus on the ILD deposits and it records a wide assemblage of minerals detected together with sulfates.

CRISM analyses: Constraining the mineral diversity. In addition to Mg/Fe-rich MHS and PHS previously detected by OMEGA, a wide array of other hydrated minerals might be present. Previous CRISM studies show a variety of spectral features in the 2.2 - 2.4 μm range across the whole VM and MT areas, that

cannot be attributed to sulfates [17-28]. We focused on absorptions near 2.2 μm that are often characteristic of hydrated silicates (such as kaolinite, montmorillonite, opal, allophane, etc... associated with 1.4 and 1.9 μm features if hydrated) but are also present in some sulfate species such as gypsum (2.22+ 2.27 associated with 1.45, 1.75, 1.94, 2.5 μm features), jarosite (2.21+ 2.26 associated with 1.46, 1.85, 2.4-2.5 μm features), alunite (2.17 associated with 1.4-1.5, 1.76, 2.52 μm features), hydroxylated Fe-sulfates and in some oxides such as gibbsite.

Absorptions near 2.2 μm are present in many spectra collected over the ILDs of both VM and MT. The exact position of these absorptions is centered at different wavelengths: 2.17; 2.21; 2.23 or 2.27 μm . Some absorptions have a doublet shape with minima at 2.21 and 2.27 μm . Therefore we decided to classify these detections in a minimum of 3 categories:

Group 1: Spectra with a sharp 2.231 μm absorption. Such spectral features have been observed in one or multiple CRISM observations in (from bottom to top, fig.1) : Aureum Chaos, Ophir Chasma, Aram Chaos (2 locations), Capri Chasma and Juventae Chasma.

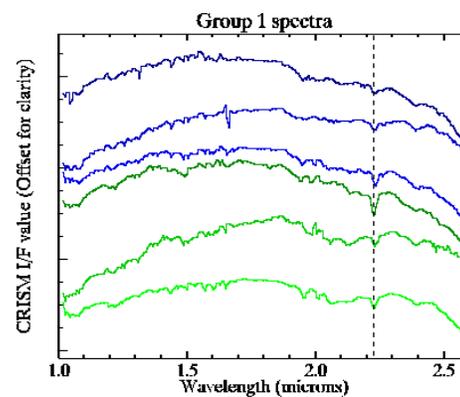


Figure 1: raw CRISM spectra of group 1

The sharp, 2.23 absorption is associated with weaker spectral features near 1.43-1.45, 1.94-1.95, and 2.40 μm . Additional bands at 2.13 μm are sometimes present suggesting that this phase is mixed with the Mg-rich MHS (kieserite) commonly detected within the ILDs. Previous studies [17-22] proposed various interpretations for these absorptions including diverse hydrated silicate mixtures. Interestingly, some authors

[17,18] attempted to correlate this set of absorptions to the Fe^{3+} -OH site in close proximity to sulfate. This spectral phase could correspond to dehydration products of Fe-rich sulfates such as copiapite [17], H_3O^+ -jarosite, melanterite or szomolnokite [18,19]. However, the group 1 material is not fully dehydrated because water bands are still present in the spectra. Alternatively it could be the signature of hydroxylated, anhydrous Fe-sulfates mixed with other hydrated minerals.

Group 2 : Spectra with a 2.21/2.27 μm doublet absorption. Such spectral features are usually attributed to metal-OH vibrations and have been observed in one or multiple CRISM observations in (from bottom to top, fig.2): Candor Chasma, Juventae Chasma, Melas Chasma, Ius Chasma and Ophir Chasma (2 locations), and are also reported in Noctis Labyrinthus [26-28]. Initially reported as an ‘unknown hydrated mineral’ by Roach et al. [20], this phase characterized by a doublet with minima at 2.21 and 2.27 μm is associated with water absorptions at 1.9 and 1.4 μm , and a drop in reflectance at 2.4 μm , usually diagnostic of PHS. The relative depths of the 2.21 and 2.27 μm absorptions vary, suggesting that this doublet signature might be a combination of absorptions from two or more different minerals. As this newly recognized hydrated mineral phase does not correspond to any single mineral within the spectral library, we suggest it corresponds to a mixture of some of the following: (1) Mg or Fe-PHS, with (2) sulfates structurally similar to jarosite and/or (3) a combination of opal and Fe-bearing smectites and/or (4) a combination of Al- and Fe -bearing smectites and/or (5) acid-leached Fe-bearing smectites [23,28].

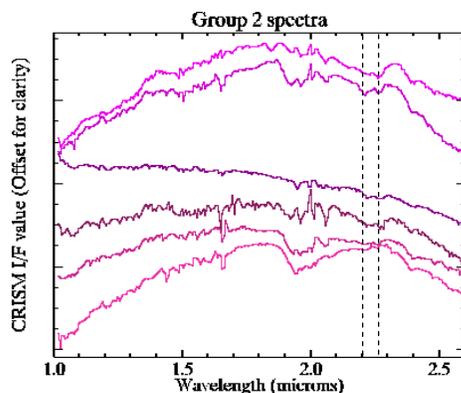


Figure 2: raw CRISM spectra of group 2

Group 3: others. Other spectral features observed in Valles Marineris include sharp 2.27 μm (fig.3, sp.1-4) absorptions sometimes associated with 1.9 and 2.4 μm absorptions but also 1.85 μm (fig3, sp.2, Ophir) or 1.75 μm bands (fig.3, sp.3,4, Melas), possibly implying a relationship to the materials present in Group 2 (re-

sponsible for the 2.27 μm absorption in the doublet) mixed with PHS, jarosite, bassanite or gypsum. A single spectral type with a wide 2.20 μm absorption (fig.3, sp.5) was found in Melas Chasma and is consistent with opal silica as previously suggested by [17].

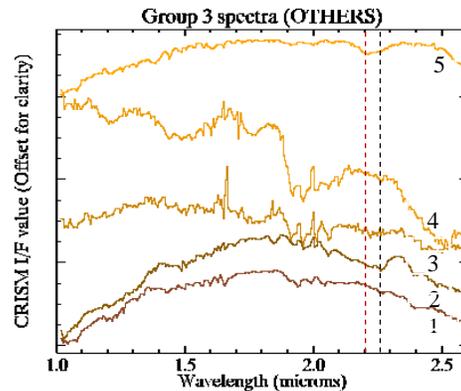


Figure 3: raw CRISM spectra of group 3

Future work: Multiple minerals appear to be present together with sulfates with the ILDs of VM and MT, such as: opal silica, Fe and/or Al-rich smectites, gypsum, jarosite, (partially) dehydrated Fe-sulfates. More work is required to characterize the context of these detections and will be presented at the conference. In particular, the type of material carrying the detections and its relationship to the ILD material is the focus of ongoing work.

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