

# GEOLOGIC ANALYSIS OF VARIOUS HYDRATED FORMATIONS EXPOSED ON THE PLATEAUS SURROUNDING VALLES MARINERIS, MARS .

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**Introduction:** Hydrated minerals were recently detected on different formations located both on the Noachian and the Hesperian plateaus surrounding the Valles Marineris Chasmata [1-11]. Their analysis may provide better constraints on the past geological history of the region. Here we report an inventory of these hydrated formations by presenting their morphology, their spatial distribution, their mineralogical composition, and their stratigraphy.

**Fe/Mg-phyllsilicate-rich formations:** The Fe/Mg-phyllsilicate-rich formations are enriched in Fe/Mg-smectite or possibly vermiculite locally (CRISM spectra exhibit absorption bands at 1.4  $\mu\text{m}$ , 1.9  $\mu\text{m}$ , and 2.3  $\mu\text{m}$ ). These light-toned formations are located both on Noachian and Hesperian terrains, and are characterized by various morphologies ranging from bouldery to thinly layered according to the geological contexts. A Fe/Mg-phyllsilicate-rich formation occurs along scarps such as in the upper parts of crater rims, valleys [9], and walls of Coprates Catena [4] and Ganges Chasma. Other formations are localised in central peaks, pits [6], and ejecta of impact craters that suggests these formations correspond to excavated layers. Layered formations correspond to valley and crater infillings, such as in Holden Crater [12] and in Shalbatana Vallis.

**Al-phyllsilicate-rich formation:** The Al-phyllsilicate-rich formation corresponds to dozens of thin light-toned exposures scattered over an area wider than 1000 x 600 km on the plateaus south of Coprates-Capri-Eos Chasmata, and west of Ganges Chasma [10]. They crop out locally on ejecta of large impact craters. This formation is also visible along scarps such as the upper parts of the walls of Coprates Catena [4] and Allegheny Vallis. The Al-phyllsilicate-rich formation corresponds to massive, rough, and polygonally fractured terrains enriched in Al-smectite and/or kaolinite (CRISM spectra display absorption bands at 1.4  $\mu\text{m}$ , 1.9  $\mu\text{m}$ , and a narrow band at 2.2  $\mu\text{m}$ ). All outcrops investigated so far are only present over Noachian terrains corresponding to volcanic materials and impact breccia (units Npl<sub>1</sub>, Npl<sub>2</sub>, and Nplh in [13]). This indicates that the Al-phyllsilicate-rich formation was formed either at the Noachian Epoch, or later by aqueous alteration of the Noachian rocks.

**LD formation:** The Layered Deposit (LD) formation occupies a large area of at least 40000 km<sup>2</sup> distributed at various elevations, both on plateaus and in shallow depressions north of Tithonium Chasma, south of Ius Chasma, around West Candor Chasma, and southwest of Juventae and Ganges Chasmata [1, 7, 8, 11]. The LD formation consists of a series of alternating light and dark beds, polygonally fractured, a hundred meters in total thickness that is covered by a dark unconsolidated mantle probably corresponding to lag deposits. The large spatial coverage of LDs and their location on highly elevated plateaus suggest that they mainly correspond to consolidated airfall dust and/or volcanic ash [7, 11]. The LD formation is composed of opaline silica or Al-phyllsilicate-rich layers being overlain by hydroxylated ferric sulfate-rich layers [1, 3, 7, 8, 11]. The stratigraphic relationships of the LD formation with the plateaus indicate that it was deposited during the Early to Late Hesperian, and possibly later depending on the region.

**Stratigraphy:** The Al-phyllsilicate-rich formation overlies the Fe/Mg-phyllsilicate-rich formation cropping out along the upper parts of scarps in several locations in the region. This sequence is topped by the LD formation. This kind of mineralogical stratigraphy is observed in other extended regions of Mars including Mawrth Vallis [14], and Meridiani Planum [15], which may have registered similar geological events. Such a mineralogical stratigraphy may be explained by an evolution of the aqueous conditions through time (e.g., alkaline to acidic alteration fluids, decreasing water/rock ratio), and by the different nature of the parent rocks (lavas, impact breccia, ash/dust).

**References:** [1] Milliken R. E. et al. (2008) *Geology*, 36, 847-850. [2] Mustard J. F. et al. (2008) *Nature*, 454, 305-309. [3] Bishop J. L. et al. (2009) *JGR*, 114, E00D09. [4] Murchie S. L. et al. (2009) *JGR*, 114, E00D06. [5] Carter J. et al. (2009) *LPS XL*, Abstract #2028. [6] Quantin C. et al. (2009) *LPS XL*, Abstract #1651. [7] Le Deit L. et al. (2009) *LPS XL*, Abstract #1856. [8] Weitz C. M. et al. (2010) *Icarus*, 205, 73-102. [9] Buczkowski D. L. et al. (2010) *LPS XLI*, Abstract #1158. [10] Le Deit L. et al. (2010) *LPS XLI*, Abstract #1146. [11] Le Deit L. et al. (2010) *Icarus*, in review. [12] Milliken R. E. et al. (2007) *LPS XXXVIII*, Abstract #1913. [13] Scott D. H. and Tanaka K. L. (1986) *USGS I-1802-A*, 1:15M scale. [14] Bishop J. L. et al. (2008) *Science*, 321, 830-833. [15] Wray J. J. et al. (2009) *GRL*, 36, L21201.