

MINERALOGY AND GEOLOGY OF THE SULFATE-RICH DEPOSITS OF CAPRI CHASMA, VALLES MARINERIS, MARS. J. Flahaut¹, C. Quantin¹, P. Allemand¹ and P. Thomas¹. ¹Laboratoire des Sciences de la Terre, UMR CNRS 5570, Ecole Normale Supérieure de Lyon/ Université Claude Bernard, 2 rue Raphaël Dubois, 696222 Villeurbanne Cedex, France (jessica.flahaut@ens-lyon.fr).

Introduction: Sulfates were discovered by OMEGA the spectral imager, onboard Mars Express, at various locations on the planet Mars [1]. Sulfates have been detected in the Valles Marineris area, near the northern cap in Utopia Planitia and locally in plains as Terra Meridiani [2]. They have also been discovered in situ by the two Mars Exploration Rovers, Spirit and Opportunity in Gusev Crater and Meridiani Planum [3-5].

All these previous missions results have suggested that the sulfate occurrence is strongly linked with the water and climate history on Mars. The recent imaging spectrometer onboard the MRO spacecraft, CRISM, enabled to refine the distribution and mineralogical composition of the hydrated minerals previously detected by OMEGA [6]. Indeed with its spatial resolution up to 18m/px, CRISM is in average 15 times more precise than OMEGA. The present study focus on these deposits in a part of the Valles Marineris system called Capri Chasma. Valles Marineris is a important area to study as it represents the largest sulfates reservoir known on Mars, and it is associated to enigmatic terrains: the Interior Layered Deposits (ILD). ILD are eroded plateaus of several kilometers of layered material which appear on the floor of most chasmata. Their origin and age is still unknown [7]. Various hypotheses for the formation of sulfates in this area and in Valles Marineris in general, and their consequence on the ILD formation scenarios, are discussed in the present work.

Spectral identification: Hydrated minerals are identified with CRISM by investigating the overtones and combinations of fundamental vibrational absorption features in the 1.0- 2.6 μm interval. Three remarkable spectral types were detected. The most common spectral type has been observed on more than 20 CRISM observations and exhibit strong absorption bands at 2.1 and 2.4 μm . The 2.4 μm feature is common to all sulfates and characterizes the SO_4 group vibrations in the structure. The shift of the bound water vibration from 1.9 to 2.1 μm in these spectra indicates the presence of a single water molecule in the sulfate structure. The combination of these two absorption features is diagnostic of monohydrated sulfates [1,8]. The general shapes of the spectra are coherent with Mg-monohydrated sulfates such as kieserite [1,8]. The second main spectral type is characterized by a broad 1.9 μm absorption band, strongly spatially correlated to the mapping of the 2.4 μm band. The coupling of these features is diagnostic of polyhydrated sulfates [1,8].

The third spectral type detected with CRISM data is found over the ILD material. This spectral type occurs very locally, and cannot be seen on OMEGA due to its spatial resolution. Spectral features include a strong double

let 2.2 μm absorption band, coupled with weaker 1.4 and 1.9 bands. Comparison with spectral libraries shows that it must be the signature of opaline silica.

Repartition and associated morphologies: Previous investigation in the area showed that the ILD constitute sedimentary deposits that had filled the canyon after its opening, during the Hesperian [7]. All the sulfates detections occur in correlation with the outcrops of light-toned deposits of the ILD. Monohydrated sulfates signature are generally found in association with the very bright and massive high albedo deposits of the flanks of the ILD [7,8] while polyhydrated sulfates are detected over distinct layers, morphologically darker and flatter, and located respectively at the bottom and at the very top layer of the ILD mounds. The top of the ILD is covered with dust, morphologically flat and spectrally mute.

Opaline silica detection are limited to a gray material forming two small mounds, a hundred meters wide, lying over the ILD material [8]. Hydrated silica have already been reported in association with sulfates on some CRISM observations in other places of the surface of Mars [9].

Conclusion: Both types of sulfates are detected in Capri Chasma, with alternating layers of distinct albedo and morphological styles. Hydrated silica has also been found locally, over the ILD material. The presence of these aqueous minerals implies that water played a role in their formation, at the Hesperian [8]. The vertical organization of sulfate-rich layers, with at least one monohydrated layer embedded into some polyhydrated sulfates layers, argues for a primary origin of both types of sulfates in Capri Chasma (i.e., no transformation of polyhydrated sulfates in monohydrated sulfates and vice-versa), that could be part of some repeated evaporitic sequences. After analyzing and comparing sulfate formation mechanisms on Earth, we suggest that sulfates in Capri could have been formed by direct precipitation or weathering of pre-existing ILDs, either in a water basin, under an ice cover, or by the multiple raises of a groundwater table.

References: [1] Gendrin A. et al. (2005) *Science*, 307, 1587-1591. [2] Bibring J.-P. et al. (2006) *Science*, 312, 400-404. [3] Squyres S.W. et al. (2004) *Science*, 305(5685), 794. [4] Grotzinger J.-P. et al. (2005) *EPSL*, 240, 11-72. [5] Wang A. et al. (2006) *JGR*, 111, E02S17. [6] Murchie S.M. et al. (2007) *JGR*, 112, E05S03. [7] Flahaut J. et al. (2009) *Icarus*, in press. [8] Flahaut J. et al. (2009), *submitted to JGR*. [9] Milliken R.E. et al. (2008) *Geology*, 36, 847-850.