**EXTENSIVE AND DIVERSE ALTERATION REVEALED IN NOCTIS LABYRINTHUS USING CRISM DATA.** P. Thollot[1], N. Mangold[2], S. Le Mouélic[2]. [1]Laboratoire de Géologie de Lyon (LGL-TPE), CNRS/Université Lyon 1, 69622 Villeurbanne Cedex, France (patrick.thollot@ens-lyon.fr), [2]Laboratoire de Planétologie et Géodynamique de Nantes (LPGN), CNRS/Université Nantes, 44322 Nantes Cedex, France.

**Introduction:** *Valles Marineris.* The Valles Marineris (VM) region of Mars bears various alteration minerals. Initial studies with km-scale OMEGA (Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité) data differenciated monohydrated and polyhydrated sulfates in Interior Layered Deposits (ILD) in most chasmata [1, 2], two mineral classes which can now be mapped and quantified at the regional scale [3]. Using finer resolution CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) data, sulfates and hydrated silica have been reported around Juventae, Candor and Ius chasmata on the plateau surrounding VM chasmata [4, 5], and phyllosilicates have been identified to the East on the plateau around Coprates and Ganges chasmata [6]. Current work on VM ILDs, taking advantage of CRISM data spatial resolution, is revealing the diversity of alteration minerals within and beyond the two sulfate classes initially identified [7].

*Noctis Labyrinthus.* Noctis Labyrinthus (NL) is an ensemble of depressions located at the western extremity of Valles Marineris, where an unexpected diversity of minerals, including phyllosilicates, sulfates and silica, has been recently reported [8], and its geological context discussed [9]. Expanding on these findings, we surveyed this region using 113 targeted CRISM near-infrared cubes (footprints shown in figure 1) to assess the region-wide diversity of alteration minerals.

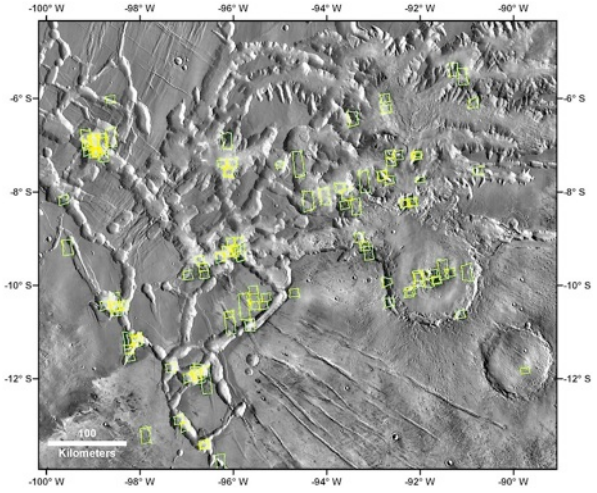


*Figure 1: Extent of the area of study with CRISM footprints in yellow.*

**Methods:** A custom batch processing pipeline was developed to rapidely process a list of CRISM observations. CRISM data were first processed through the CAT for calibration and correction of atmospheric absorptions. The signal to noise ratio was then improved using semi-automated spectral ratioing to reveal weak spectral features and filter out column-dependant artifacts. Custom spectral criteria based on the shape and combination of absorption bands were then computed to look for various alteration minerals.

**Results:** *Summary.* We found widespread occurrences of outcrops of ~10 classes of different hydrated minerals. These include Fe/Mg-phyllosilicates, Kaolinite-group minerals, silica, Ca, Mg and Fe-bearing polyhydrated sulfates (gypsum, copiapite, hexahydrite), kieserite, jarosite, alunite, and a so-called "doublet"-bearing phase.

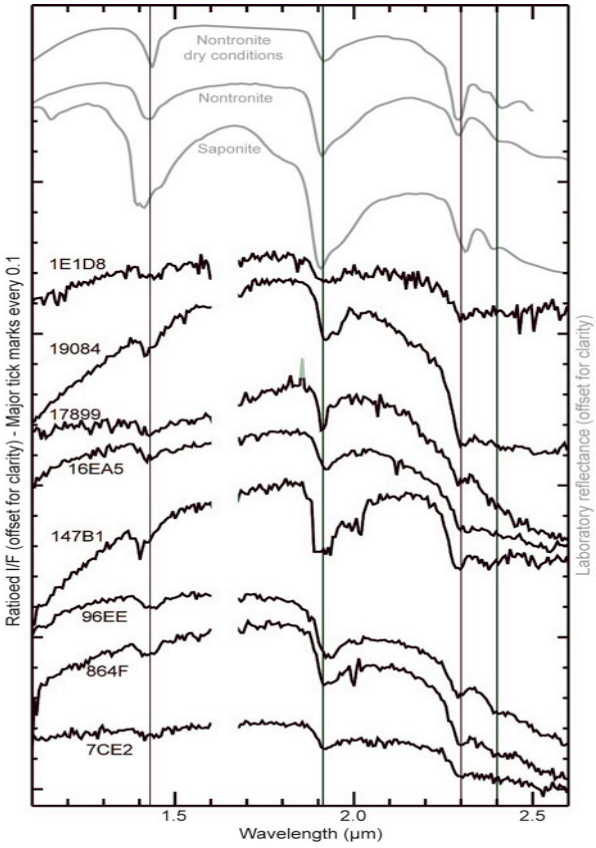


*Figure 2: CRISM ratioed spectra of Fe/Mg-smectites in NL (black) with library spectra (grey) for comparison.*

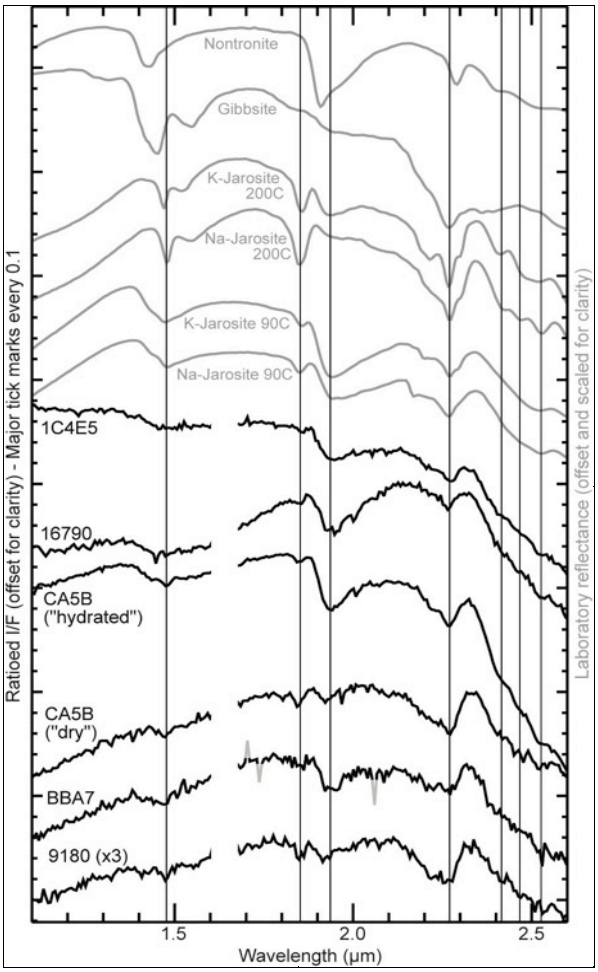


*Figure 2: CRISM ratioed spectra of jarosite in NL (black) with library spectra (grey) for comparison.*

The "doublet" phase is also being detected in a growing number of location in VM chasmata [7]. Spectra of two of these spectral classes are shown in figure 2 (with Fe/Mg-smectites) and figure 3 (Fe-sulfate jarosite). A similar frequency of occurrence has been found for most of the 10 mineral classes. Alunite only was only firmly identified in one CRISM observation.

A map of all detections of these various alteration minerals has been produced and will be presented at the conference.

**Discussion:** *Mineralogy.* Both clays and sulfates are pervasive in Noctis Labyrinthus depressions. This region shows the most widespread occurrence of jarosite-bearing materials yet reported on Mars. The association of jarosite with silica, gypsum, and, in at least one location, the rare Al-sulfate alunite argues for acidic alteration. Indeed, acidic waters greatly enhance the mobility of the elements Fe and Al.

*Geological context.* A morphological study of the region using CTX (ConTeXt imager) and HiRISE (High Resolution Imaging Science Experiment) data is revealing several clues that point to volcanic activity in at least part of NL. Coupled with the peculiar mineralogy associating silicates with sulfates, including jarosite and alunite, the morphological evidences argue for hydrothermal alteration, as proposed by [9] in one depression of NL.

*Implications.* NL alteration minerals formed more recently than most hydrous phases elsewhere on Mars, after the late Hesperian (age of the plateau cross-cut by NL depressions), when Mars climate is believed to have been cold and dry. Yet, the mineralogical diversity is as important as it ever gets on Mars. This mineralogical diversity is somewhat higher in older terrains than in younger terrains. However, the original geologic context has not always been well preserved in the former. Our understanding of the early martian environment would likely be improved if we were able to distinguish similar hydrothermal settings from surface environments in the oldest (ie. Noachian) terrains.

**References:** [1] Gendrin A. et al. (2005) *Science, 307(5715)*, 1587-1591. [2] Bibring J. P. et al. (2006) *Science, 312(5772)*, 400-404. [3] Thollot P. et al. (2014), *this meeting*. [4] Milliken R. E. et al. (2008) *Geology, 36(11),* 847-850. [5] Le Deit L. et al. (2010) *Icarus, 208*, 684-703. [6] Le Deit L. et al. (2012) *JGR, 117*, E00J05. [7] Flahaut J. et al. (2014), *this meeting*. [8] Weitz C. M. et al. (2011) Geology, 39(10), 899-902. [9] Thollot P. et al. (2012) *JGR 117*, E00J06.