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Regional hydrothermal alteration in Noctis Labyrinthus: scattered, yet pervasive.

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Abstract

We analyzed 113 CRISM cubes in Noctis Labyrinthus. We found 10 classes of alteration minerals including clays and sulfates, sometimes associated in the same setting. Fe and Al sulfates argue for acidic hydrothermal alteration.

1. Introduction

The Valles Marineris (VM) region of Mars bears various alteration minerals, as initially revealed by km-scale data from OMEGA (Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité) [1,2], and which diversity has been assessed by numerous local studies using finer resolution (tens of m) data from CRISM (Compact Reconnaissance Imaging Spectrometer for Mars). These minerals include Fe-oxides and sulfates in the chasmata and hydrated silica or phyllosilicates on the surrounding plateaus [3].

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 [4], and its geological context discussed [5]. 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.

2. Data analysis showing a larger diversity of alteration minerals than for contemporaneous terrains

A custom batch processing pipeline was developed to rapidely process a list of CRISM observations, based on calibration and correction routines of the CAT, as well as a custom spectral ratioing procedure to filter out column-dependant artifacts and improve signal-to-noise. Custom spectral criteria, based on the shape and combination of absorption bands, were then computed to look for various alteration minerals.

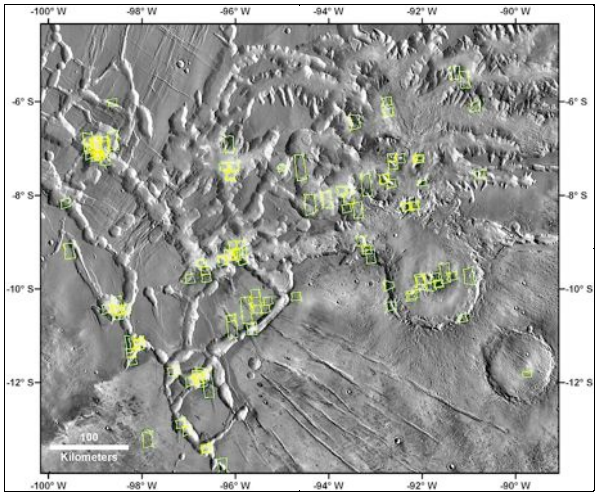

Figure 1: Extent of the area of study with CRISM footprints in yellow.

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 (Figure 2), alunite, and a so-called "doublet"-bearing phase.

3. Discussion

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 (see spectra in Figure 2). The association of jarosite with silica, gypsum, and, in at least one location, the rare Al-sulfate alunite argues strongly for acidic alteration. Indeed, acidic waters greatly enhance the mobility of the elements Fe and Al.

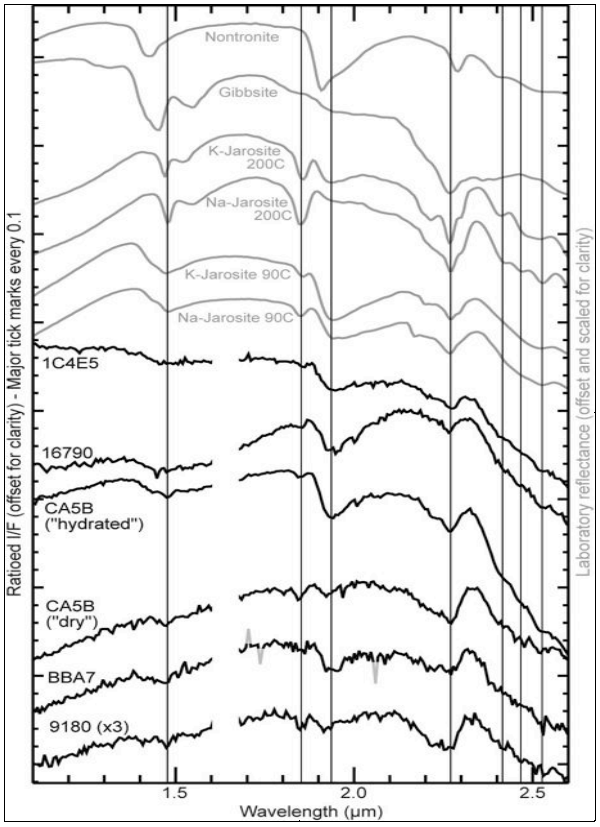

Figure 2: CRISM ratioed spectra of jarosite in NL (black) with library spectra (grey) for comparison.

A morphological study of the region using CTX (ConTeXt imager) and HiRISE (High Resolution Imaging Science Experiment) data is revealing several clues (ash layers, volcanic vents, lava flows) that point to volcanic activity in at least parts of NL. Coupled with the peculiar mineralogy associating silicates with sulfates, including jarosite and alunite, the morphological evidences argue for hydrothermal alteration, as proposed locally by [5] for one depression of NL, but as a major regional occurrence, over as much as several hundreds of km squared.

On a global scale on Mars, the mineralogical diversity is somewhat higher in older terrains than in younger terrains. NL, being one of the latter, appears to stand at odds with this global trend, which may be related with the long-lived magmatic activity of the Tharsis province.

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 study shows that despite a changing, drying, surface environment, there were regional locations on Mars possibly hosting habitable conditions, in hydrothermal settings, further down the history of the planet.

This work also gives insights, by analogy, on the possible role of hydrothermal processes in the formation of sulfates and other alteration minerals found in VM Interior Layered Deposits.

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