IDENTIFICATION OF PHYLLOSILICATES IN CRUSTAL OUTCROPS BETWEEN HELLAS AND ISIDIS BASINS (MARS) USING COMBINAISONS OF NEAR 2.3-2.5µm ABSORPTIONS ON CRISM DATA.

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Introduction: Characterization of water/rock interactions on Mars is crucial to constrain the hydrological evolution of the planet. OMEGA (Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité) and CRISM (Compact Reconnaissance Imaging Spectrometer of Mars) both hyperspectral imagers respectevely onboard Mars Express and Mars Reconnaissance Orbiter (MRO) have largely reported presence of phyllosilicates in Noachian terrain [1], [2] which allow to speculate on the early environments.

The phyllosilicates detected for now on Mars are smectites, chlorites, kaolinite, talc and most recently serpentine [3], [4]. The observation of serpentine on Mars is a ground-breaking result. Indeed, the serpentinization reaction releases H_2 which could serve as energy for the emergence of life [5].

In the Early and Medium Noachian terrains, serpentine have been detected in Claritas Rise, Nili Fossae and Syrtis Major [6] but no definitive detection has been reported between Hellas and Isidis Basins. However, according to OMEGA global map, this region is enriched in ultramafic rocks [7]. As serpentine is an alteration product of ultramafic rocks, we should expect serpentine-rich outcrops. In the present work, we study in detail all the available CRISM data cubes between Hellas and Isidis basin seeking for phyllosilicates. We focus our work on the shift in the absorption near 2.3 and 2.5µm. This shift gives us the opportunity to discriminate the phyllosilicates resulting from the hydration of ultramafic rocks. After the presentation of the data set and the developed methodology, we present and discuss the results.

Data and method:

CRISM data are pre-processed with the CRISM Analysis Toolkit (CAT) [8]. We next develop a personal pipeline to remove noise of CRISM data combining mobile average, mobile median and sharpening-median filters. We test our noise removal pipeline on library spectra. We artificially add noise to library spectra to test our noise removal pipeline. For instance, a library spectrum of serpentine is presented in figure 1 as well as the artificially noised spectrum and the post-processing clean spectrum. In the 1 µm to 2.6 1 µm spectral domain, the serpentine has the following combination of absorptions: at 1.39 µm, 2.11 µm, 2.32 µm and 2.51 µm.

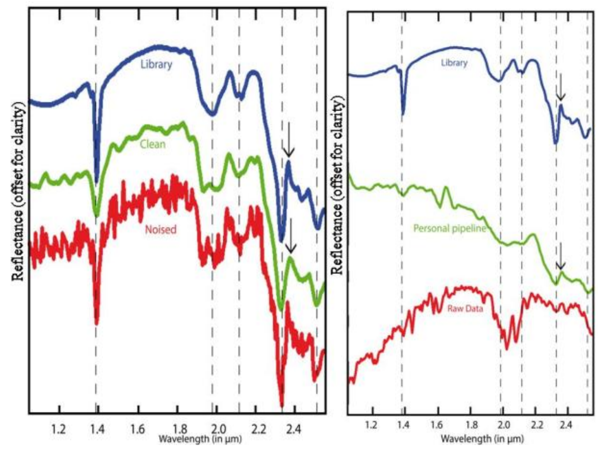

Figure 1: Left] Test of our pipeline on a library spectra from RELAB (SERPENTINE C2CR01). Right] Application of the pipline to a serpentine like CRISM spectrum. The dotted lines show the characteristic features important to conserve (1.39; 1.93; 2.12; 2.32; 2.51µm). The black arrow indicates the maximum of reflectance at 2.36µm.

Some of these spectral features being shallow as the 2.11 µm feature; we pay attention to the conservation of the characteristic of the key absorption features after the processing. After several test on library spectra we validate our noise removal pipeline and apply it to CRISM data (Figure 1, right).

Our pre-process also includes a ratio of each spectra of the CRISM cube by an average spectrum of the cube to remove the contribution of the atmosphere and the average dust contribution.

Geological setting of the detections: Most of the geological context of the CRISM targeted observations in this region are impact craters. We use these impact craters as natural drills to investigate the ancient crust. The observations on a single crater over its ejectas blankets, its walls or its central peak allow us to reconstruct the pre-impact geological cross-section. The diameter of studied craters ranges from 6 to 80 km, giving us to access to a large range of crustal depth.

Results:

We identify the following phyllosilicates in 26 CRISM cubes: Chlorites, serpentines and smectites. The figure 2 presents the assemblage of smectite with serpentine in a central peak of an impact crater. Over the whole studied region, we detect the following assemblages: chlorite alone, chlorite and smectite, chlorite and serpentine or Chlorites, serpentines and smectites. These various assemblages are detected in the various parts of the impact crater: central peak, walls and ejecta blankets.

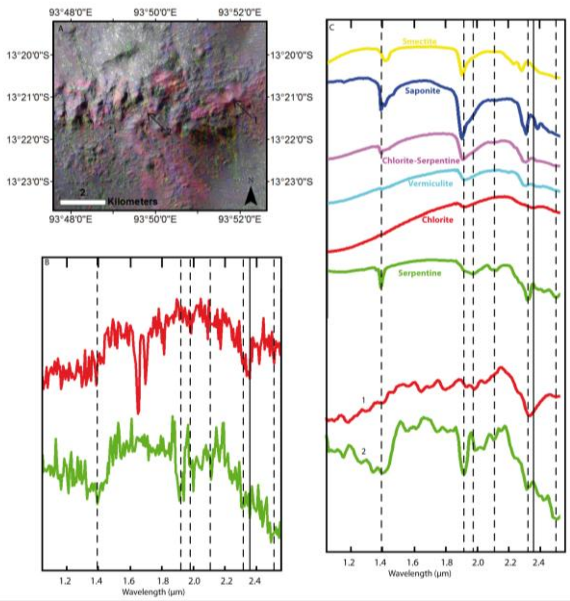

Figure 2: A] CRISM-RGB composition over a CTX image. Serpentine appears in Yellow to Green, chlorite in Purple to blue and smectite in Red. B] Raw ratioed spectrum of pixel 1 and 2 located in A. C] cleaned ratioed spectrum of pixel 1 and 2 compared to library spectra.

We analyze the mineralogical assemblages according to the diameter of the impact crater and according to the age of the impact crater (Figure 3). Assuming that the phyllosilicates predate the impact craters, we also analyze the distribution of the assemblage according to the pre-impact depth of the exposed rocks. It seems that a relationship exists with the pre-impact depth: assemblages with smectite are restricted in the rocks coming from the upper part of the crust while assemblages with serpentine and chlorite are more widely distributed in the crustal cross section.

We determine the ages of the studied impact craters (figure 3) using the small crater population and the crater count techniques [9]. The ages of the studied craters range from 500 My to 3,75 Gy. There is no clear relationship between the ages of the crater and the exposed mineralogy.

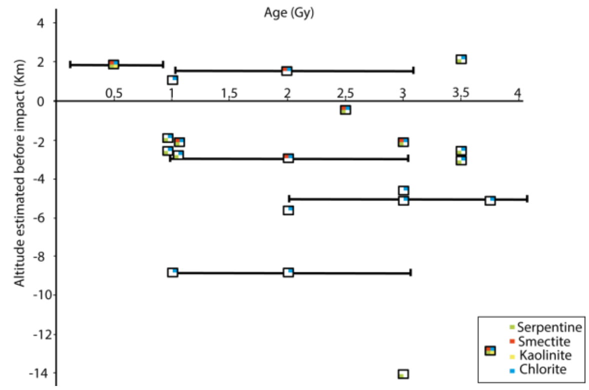

Figure 3: Pre-impact elevation of the exposed rocks enriched in plyllosilicates vs estimated ages of impact crater from crater count techniques[9].

Discussion/Conclusions:.

Our results on impact crater raise a discussion about the origin of the alteration: it is either due to impact-induced hydrothermalism [10] or the alteration predates the impact. Also, our results raise a discussion about the origin of mineralogical diversity: Did a variable amount of water and /or a variation of the gradient of pressure and temperature could be the source of the mineralogical diversity? And finally, are all these conditions compatible with a habitable environments?

References:

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