



Analysis of the 3 μm spectral features of Mg-rich phyllosilicates with temperature variations in support of the interpretation of small asteroid surface spectra

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1. Introduction

Recent spectral orbital data revealed the presence of hydrated minerals on the surfaces of small bodies, mainly thanks to the identification and the study of spectral features around 3- μm [1, 2]. These features, widely detected on the spectra of carbonaceous chondrites, are indicative of the presence of (OH)-bearing minerals. However, their appearance and shape are diverse indicating different composition and/or the occurring of subsequent alteration events. It has been suggested that thermal alteration processes, can darken the surfaces of carbonaceous chondrites, thus decreasing the reflectance values around 3 μm . Thermal alteration processes, have been considered to explain the formation of 162173 Ryugu asteroid [3]. The Near Infrared Spectrometer (NIRS3) on Hayabusa 2 mission detected a weak and narrow absorption feature centered at 2.72 μm across the entire observed surface of the C-type asteroid [2]. However, the collected spectra from the Ryugu surface show no other absorption features in the 3- μm region. To investigate on this point and to check the behaviour of the spectral features around 3 μm with thermal alteration, we performed laboratory experiments on two Mg-rich phyllosilicates (serpentine and saponite). In particular, we studied two different situations: 1) thermal alteration at increasing T - the samples were heated at different steps of 100 $^{\circ}\text{C}$, starting from 100 $^{\circ}\text{C}$ up to 700 $^{\circ}\text{C}$, for 4 hours each; 2) long time heating at constant T - samples were heated at constant T \sim 250 $^{\circ}\text{C}$ for 1 month (1st step) and then for 2 months (2nd step).

2. Experimental setup and procedure

We selected four samples of serpentine and saponite in two different grain sizes: 25-63 μm and 125-250 μm . Samples preparation, heating processes and measurements were performed in the Planetary Spectroscopy Laboratory (PSL) of the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt, DLR) in Berlin [4]. Three identical FTIR (Fourier Transform Infrared Spectrometers) instruments are operated at PSL, in an air-conditioned laboratory room. The three spectrometers are all the same identical model, Bruker Vertex 80V that can be evacuated to \sim .1 mbar. Two spectrometers are equipped with aluminium mirrors optimized for the UV, visible and near-IR, the third features gold-coated mirrors for the near to far IR spectral range. Using three instruments that are identical (apart from the different internal mirrors) has some major benefits. Most importantly, it facilitates the cross-calibration between the three instruments. The instruments can also share the collection of detectors, beam splitters, and optical accessories that are available in our equipment to cover a very wide spectral range.

In the first part of our experiment, samples were heated in vacuum (~ 0.1 mbar) using the induction system in the external emissivity chamber of the PSL. The temperature of the sample was increased slowly and gradually up to the desired value. T was controlled by means of temperatures sensors located inside the chamber, in contact with the sample cup (stainless steel) rim and bottom part. After reaching the targeted T, the samples were kept stable at these temperature and pressure conditions for ~ 4 hours. After each step, the heated samples were cooled down in vacuum and then measured in the whole spectral range (from UV to IR) in bidirectional reflectance. In parallel, two of the selected samples (serpentine 125-250 μm and saponite 125-250 μm) were stored in two autoclaves in an oven at 250°C for 1 month (first set of samples), and then once again at the same temperature for two months (second set of samples). The 1-month and 2-months heated samples, after cooling down in the autoclaves, were measured in reflectance, with the same experimental setup used for the samples heated at different T steps. Bidirectional reflectance measurements were recorded in vacuum by using two of the Bruker Vertex80V FTIR spectrometers at PSL in two different angles configurations: 1) $i=0^\circ$ $e=26^\circ$; 2) $i=0^\circ$ $e=40^\circ$.

3. Results and discussion

The spectra acquired on the fresh and thermally processed samples of saponite (125-250 μm) are shown in **Fig. 1**.

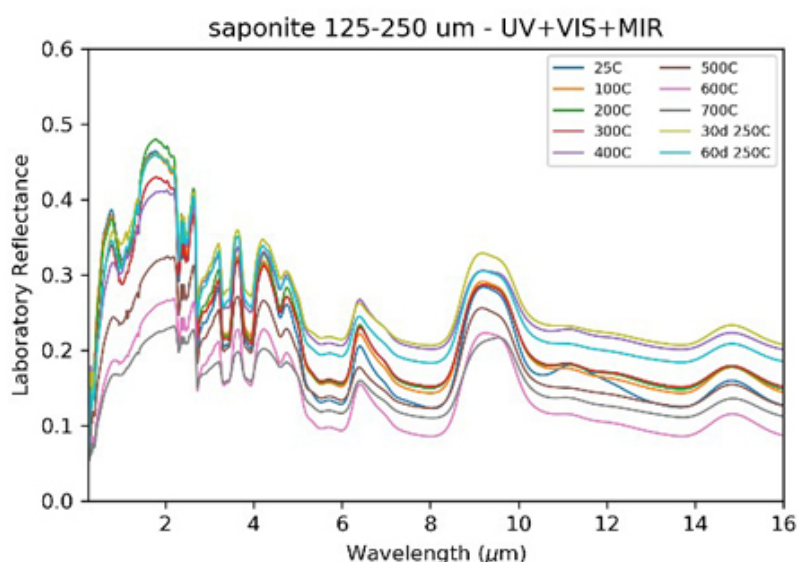


Fig. 1. Spectra of saponite 125-250 μm in the full studied range.

Globally it is possible to observe: - a darkening effect occurring at High-T in the UV+VIS spectral range for both the analyzed samples; - a decreasing intensity with increasing T in the spectral features present in the region 0.35-0.7 μm ; - general darkening has not been observed in the MIR spectral range; - a 0.95 μm (water absorption band) and a 2.3 μm (absorption usually attributed to Mg-OH stretching) features decrease with increasing T in both serpentine and saponite samples. Isolated bands and spectral parameters have been retrieved for a detailed study of the spectral features around 3- μm . We observed that: - the 2.7 μm feature is most prominent in the saponite samples and it tend to decrease with Hi-T, but without totally disappearing; - the intensity of the 2.7 μm feature features strongly decrease instead in the samples of serpentine, especially in the long heated ones; - a 3.4 μm feature is present in the spectra of high-heated serpentine from 300°C on for the 25-63 μm serpentine, and for the sample of 125-250 μm serpentine heated at 600°C and 700°C.

References

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