Spectral variations in serpentine and saponite 2.7 µm band due to heating under vacuum.

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Introduction: Carbonaceous chondrites (CCs) are scientifically significant as they present a window into the early Solar System. Many classes of meteorites are considered primitive and provide an opportunity to study early solar system chemistry [1]. Carbonaceous chondrites in the sub-group CM2 likely underwent aqueous alteration to various degrees, resulting in formation of alteration minerals such as phyllosilicates [2]. Here we present a heating experiment conducted on two phyllosilicates and a simple two-component phyllosilicate + carbonaceous phase spectral analogue powder created at the Centre for Terrestrial and Planetary Exploration (C-TAPE) at the University of Winnipeg, Canada.

Methods: Samples of saponite (C-TAPE ID: SAP104), serpentine (C-TAPE ID: ASB267), and CC spectral analogue, created in-house, MUD008 (C-TAPE ID) were heated up to 900˚C under vacuum (~0.07 mbar) in 100°C increments for 1 hour at each temperature increment. Heating was conducted using an induction heating system in the external emissivity chamber at the Planetary Spectroscopy Lab (PSL) at DLR, Berlin. Samples were allowed to cool in the vacuum chamber and then removed from vacuum and transferred to the spectrometer. The sample was then evacuated down to ~0.1 mbar prior to the spectral measurements. Data were collected using a Bruker Vertex 80v FTIR spectrometer using the Bruker A513 bi-directional reflectance accessory. Reflectance data were collected over the VISNIR (0.4 – 1.1 µm) and MIR (1.1 – 20 µm), however for the purposes of this report, only results up to 5 µm are discussed and displayed in the figures below. A new sample was used for each temperature increment.

Results: Progressive heating of SAP104 generally displays a decrease in reflectance values as temperatures increase in the VISNIR (0.4 – 1.1 µm). In the MIR (1.1 – 20 µm), the spectra brighten slightly up to 300°C, after which the reflectance starts to decrease. The H_2O absorption feature ~2.7 µm decreases in depth with increasing temperature, displaying qualitatively the deepest band at the room temperature observation and the shallowest band at 900°C (see Figure 1).

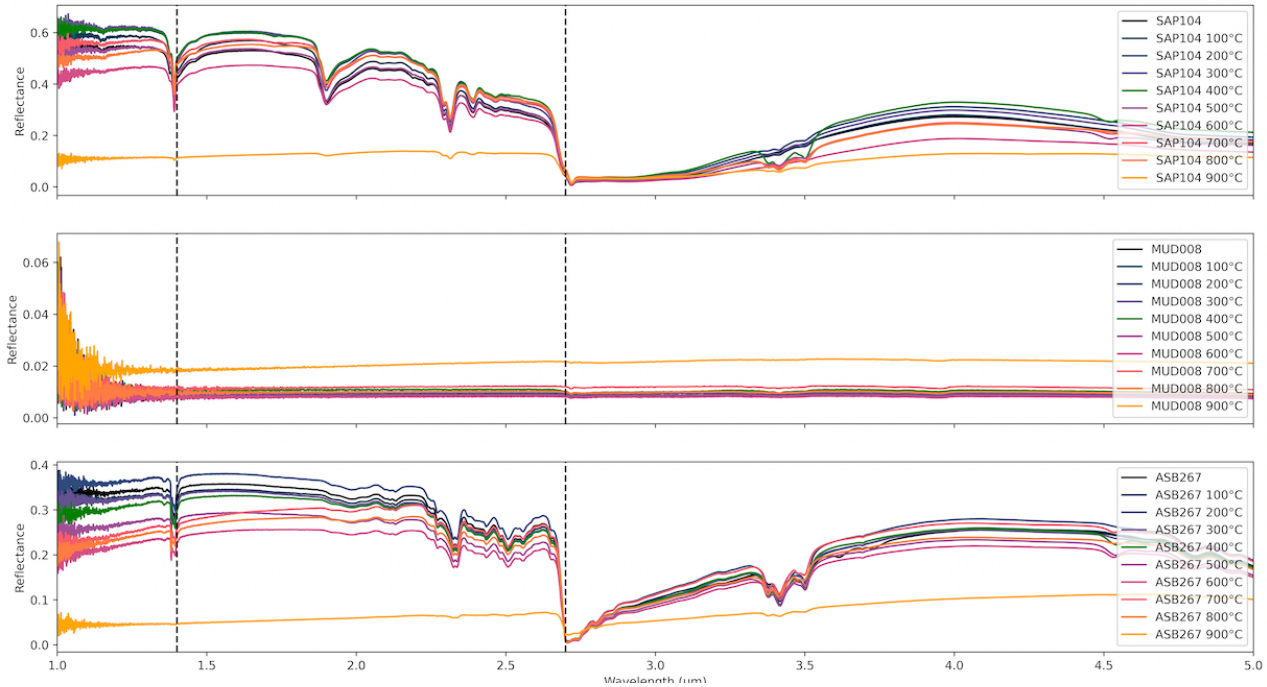

Figure 1: MIR (1-5 µm) reflectance spectra of SAP104 (top), MUD008 (middle), and ASB267 (bottom) heated up to 900°C for 1 hour at each 100°C increment under vacuum.

ASB267 displays a similar trend upon heating as SAP104's spectra regarding reflectance values: generally, decreases in the VISNIR and slightly increases then decreases in the MIR with increasing temperature. Also, similar to SAP104, the ~2.7 µm absorption feature systematically decreases in depth as a function of increasing temperature.

MUD008 (90 wt.% SAP105 saponite, <45 µm grain size + 10 wt.% LCA101 carbon lampblack, <0.021 nm grain size) gets spectrally brighter as a result of heating in both the VISNIR and the MIR, which may be due to the volatilization of carbon. MUD008 displays a slight ~2.7 µm feature which gets shallower with increasing temperature, consistent with the spectra of SAP104 and ASB267 (serpentine).

Other OH/H_2O related features ~1.4 and 1.9 µm are observable in both SAP104 and ASB267 spectra. After exposure to high temperatures, these absorption features also decrease in depth, consistent with the ~2.7 µm feature. Metal-OH features near ~2.3 µm are also visible in both phyllosilicate samples. By 900°C, the absorption features are drastically reduced in depth.

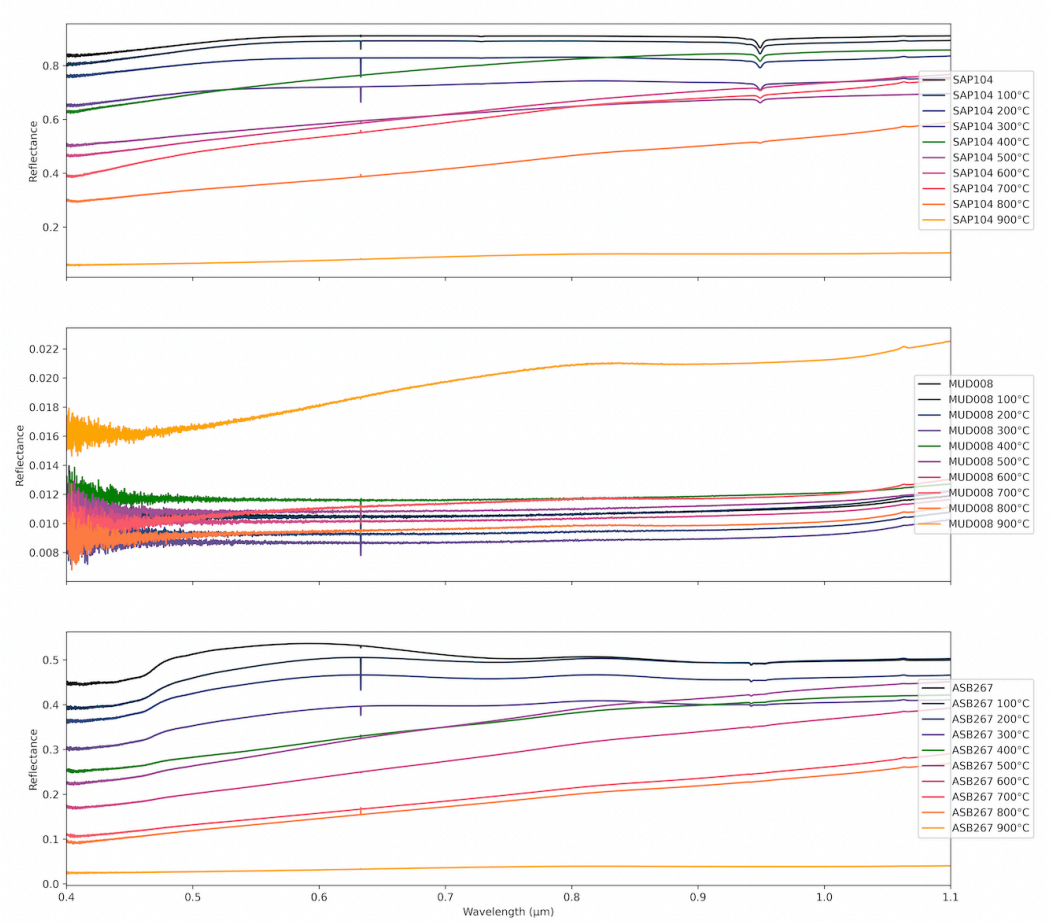

Figure 2: VISNIR (0.4 – 1.1 µm) reflectance spectra of SAP104 <45 µm (top), MUD008 <45 µm (middle), and ASB267 <45 µm (bottom) heated under vacuum up to 900°C in 100°C increments. Spectral artifact at ~0.64 µm.

Discussion: Our spectra show that several OH/H_2O absorption features at ~1.4, ~1.9, and ~2.7 µm become shallower with increasing temperature in SAP104 and ASB267. In addition, the Mg-OH features near ~2.3 µm also decrease in strength with increasing temperature in both saponite and serpentine samples. These results are part of an on-going study investigating the spectral and mineralogical variations in saponite, serpentine and MUD008 due to thermal exposure under vacuum conditions. Future work includes collecting X-ray diffraction data on the heated samples presented in this study and relate any mineralogical changes to the spectral variations observed.

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References

[1] McSween. H. 1979. Reviews of Geophysics & Space Physics 17:5. [2] Rubin. A. E. et al. 2007. Geochimica et Cosmochimica Acta 71:9.