Effects of Thermal Alteration on the Near- and Mid-Infrared Spectra of Phyllosilicates: Implications for Mars

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Introduction

- Martian phyllosilicates are Noachian in age and hold clues to Mars' early history [1, 2]
- Nontronite, montmorillonite, saponite, kaolinite, chlorite, serpentine, and prehnite are found on Mars [2-5]
- Some deposits are located in impact craters or near lava flows [2, 6]
- Spectra of nontronite and montmorillonite clearly evolve with temperature [6]

Motivation

- Understanding a deposit's thermal history:
  - Constrains depositional conditions and alteration processes
  - Provides insight into early surface conditions on Mars

Methods

- Samples heated for 24 hours between 300 and 1100°C in 100°C increments
- Samples put on a 150°C hot plate under N_2 flow for two hours before NIR spectral measurements
- NIR and MIR spectra collected using a Nicolet 6700 FTIR

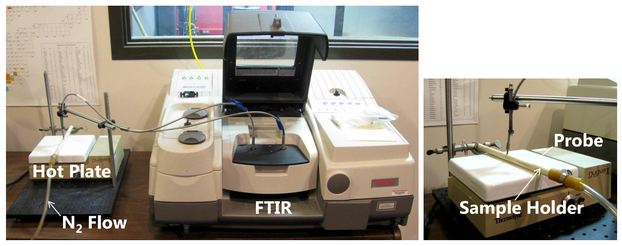

Figure 1. Setup for collecting NIR spectra.

Near-Infrared Data

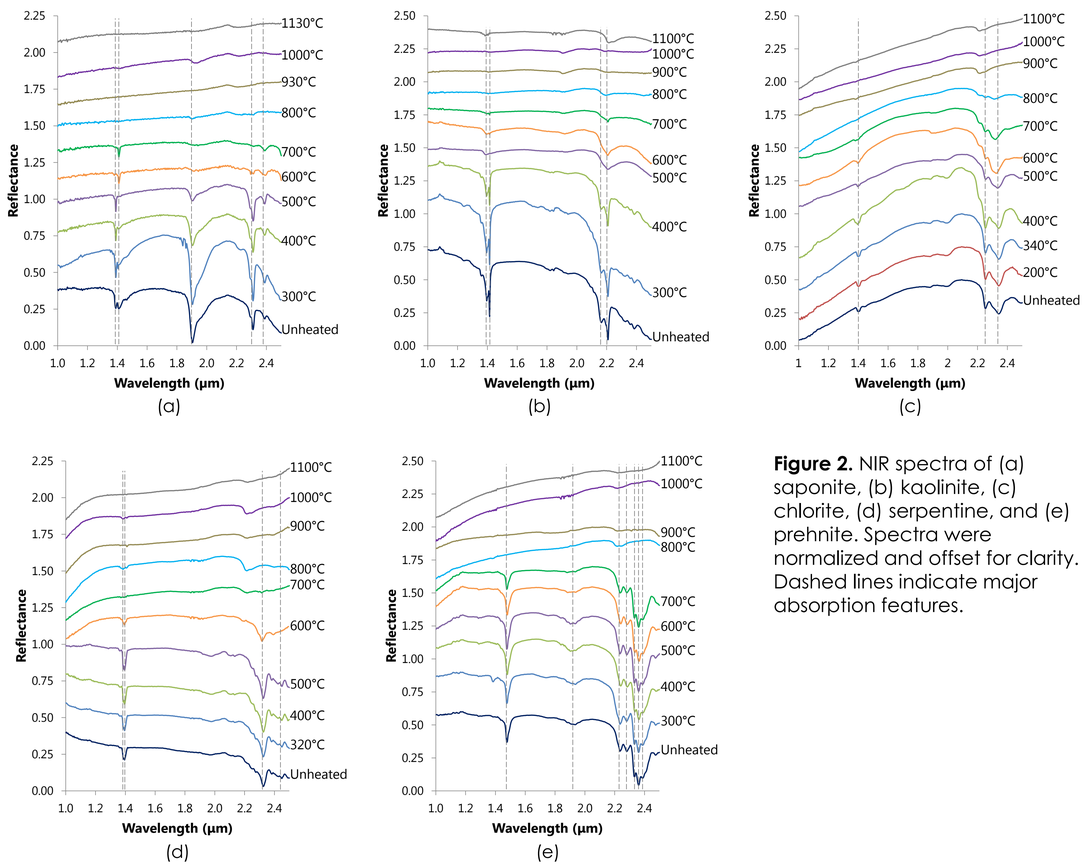

Figure 2. NIR spectra of (a) saponite, (b) kaolinite, (c) chlorite, (d) serpentine, and (e) prehnite. Spectra were normalized and offset for clarity. Dashed lines indicate major absorption features.

Mid-Infrared Data

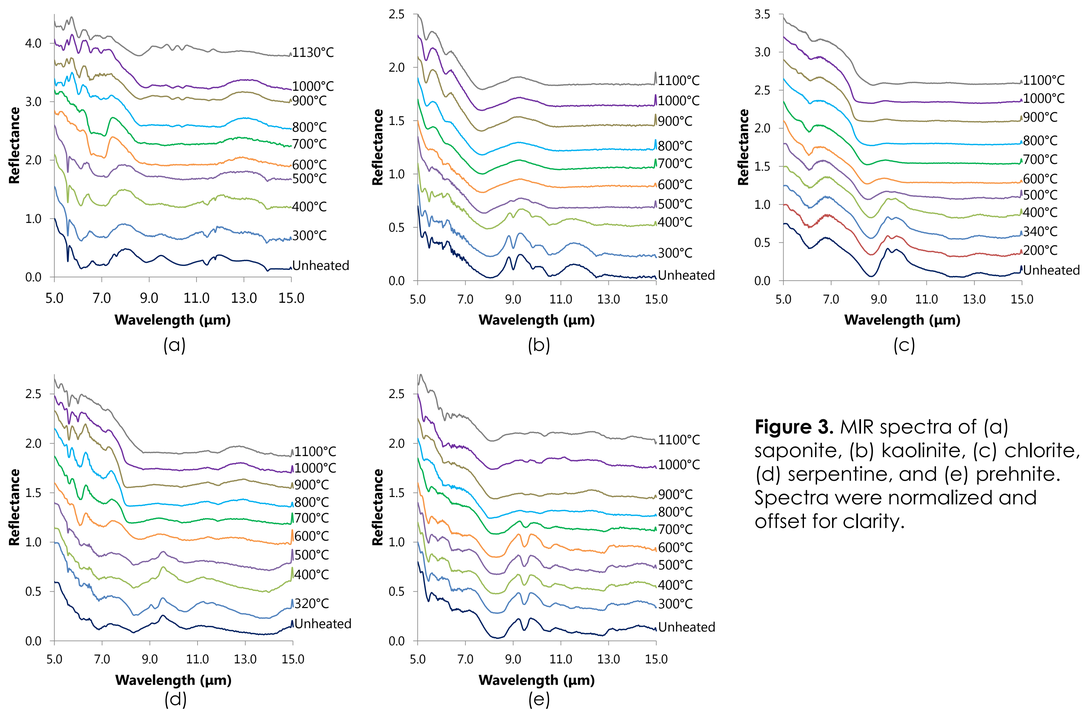

Figure 3. MIR spectra of (a) saponite, (b) kaolinite, (c) chlorite, (d) serpentine, and (e) prehnite. Spectra were normalized and offset for clarity.

Discussion

- NIR spectra a proxy thermometer for maximum alteration temperature until spectra become featureless
- High temperature secondary phases identified by MIR spectra [6]
- Metal-OH bands may shift location due to different thermal resistances of Fe-OH, Mg-OH, and Al-OH bonds [4, 6] (Fig. 4)

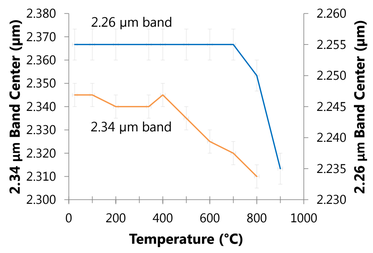

Figure 4. In chlorite the 2.26 and 2.34 µm band centers shift at high temperatures. The 2.34 µm band shifts to shorter wavelengths as Mg/Fe increases [4].

Mars Comparisons

- Saponite in a Mawrth Vallis crater [2] is likely thermally altered (Fig. 5)
- Saponite in the crater thus predates impact

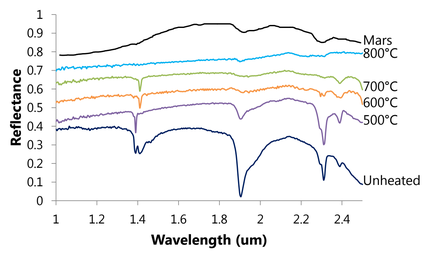

Figure 5. Comparison of CRISM saponite spectra from a Mawrth Vallis crater [2] to experimental data. The Mars spectrum has 1.9 and 2.3 µm bands but lacks a 1.4 µm band. The deposit probably contains a mixture of saponite heated to 500-600°C and saponite heated to ~800°C.

Acknowledgements

A NSF-funded REU at the Arkansas Center for Space and Planetary Sciences supported this work. Dan Ostrowski provided the serpentine samples used in this study.

References

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