COMPARING VNIR AND TIR SPECTRA OF CLAY-BEARING ROCKS

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Introduction

Clays are an important indicator of aqueous processes and have been identified in numerous locations on Mars using OMEGA and CRISM data [e.g. 1, 2]. Visible/near infrared reflectance spectra (VNIR) and thermal region infrared (TIR) data were acquired on clay-bearing rocks, rather than pure minerals, in order to enable coordinated analysis of both data sets for comparison with Martian spectra. This new data set may further TES analysis of Martian clays, as clays have not yet been observed above the detection limits in TES data using lab spectra [3].

Sample ID	Sample Name	XRD Results	Sample info
JB931	Beidellite	smectite with ~5-10% qtz	soft, white, waxy
JB1480	Hisingerite	hisingerite, siderite, quartz, feldspar, serpentine	med-hard, brown, shimmery, flaky
JB1486	Loma Mar-Lg	opal or glass, dolomite, quartz, smectites	hard, tan, grainy
JB1487	Loma Mar-Sm	smectite, opal, quartz, felspar	hard, tan, grainy
JB1488	Coyote Hills 1	quartz	hard, brown w/trnsl veins
JB1489	Coyote Hills 2	quartz	hard, red-brown w/trnsl veins
JB1490	Nontronite	smectite	med-hard, lime green, chalky

Table 1. X-Ray Diffraction data , processed at NASA-Ames on crushed samples that were sieved to 45-150 μm, and visual sample information.

Data Analysis

- VNIR spectra of phyllosilicates are best identified in remote sensing data by the OH stretching and bending combination bands near 2.1-2.4 μm [e.g. 6]
  - ~2.20-2.21 μm for Al/Si
  - ~2.29 μm for Fe^{3+}
  - ~2.30-2.31 μm for Mg
- TIR spectra of phyllosilicates exhibit bands due to Si-O bending and stretching vibrations [e.g. 10]
  - Dioctahedral phyllosilicates: bending doublet near 450-600 cm^{-1} and single stretching band near 1050 cm^{-1}
  - Tetrahedral phyllosilicates: single bending Si-O band near 475 cm^{-1}
  - Si-O stretching vibration bands occur near 1060 cm^{-1} for montmorillonite, near 1110 cm^{-1} for opal, and as a doublet for quartz

Methodology

The rocks were processed for VNIR reflectance spectra using an ASD FieldSpecPro spectrometer that measured from 0.35-2.5 μm under ambient conditions. TIR emissivity spectra were measured using the Nicolet Nexus 670 at the Arizona State University (ASU) Thermal Infrared Mineral Spectroscopy Laboratory as in previous studies [5]. All samples were heated in an oven for ~12 hours prior to measurement and retained in a 0-2% humidity chamber during measurement. XRD was run at NASA-Ames on crushed samples sieved to 45-150 μm.

Results

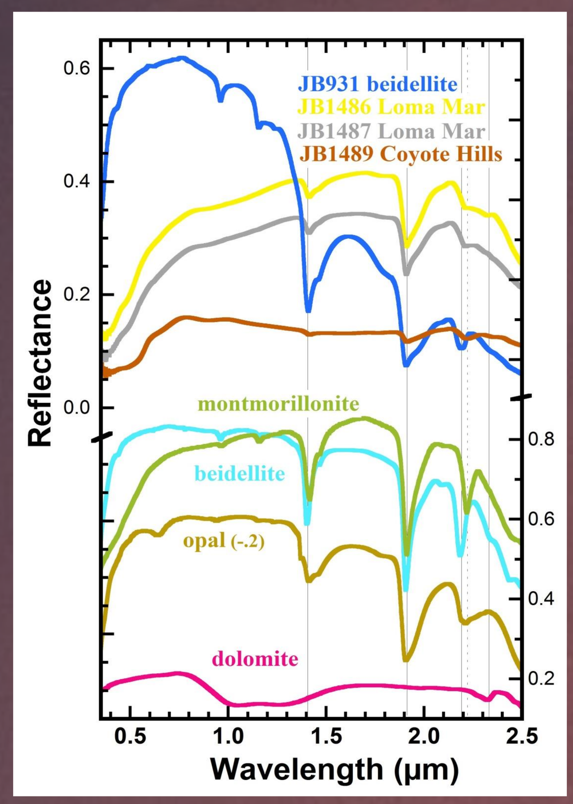

Figure 1. VNIR reflectance spectra of Al-rich clay-bearing rocks compared with spectra of minerals.

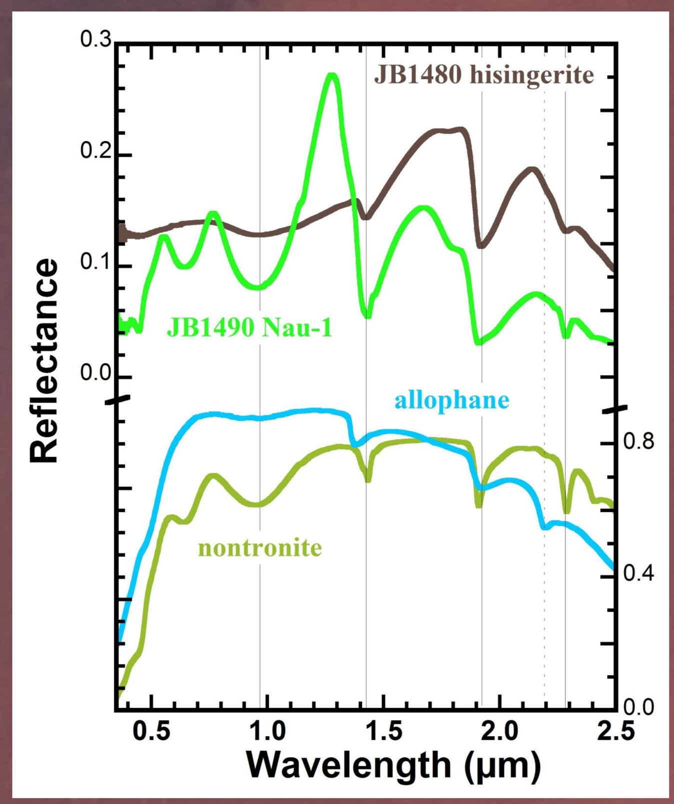

Figure 2. VNIR reflectance spectra of Fe-rich clay-bearing rocks: Nau-1 nontronite and hisingerite from Australia.

VNIR Results

- All Al-rich samples exhibit bands near 1.4, 1.9 and 2.2 μm (fig 1)
- XRD of the JB931 beidellite showed this rock to be primarily smectite with ~10 wt.% quartz (table 1 and fig 1)
- Loma Mar sample JB1486 contains dolomite, which contributes a band near 2.32 μm (fig 1)
- Nau-1 and hisingerite rocks have bands at 1.42, ~1.9 and 2.29 μm (fig 2)
- No spectrum is available for hisingerite, a spectrum of allophane is shown along with that of nontronite for comparison (fig 2)
- H_2O band occurs at 1.91 μm for nontronite (fig 2)
- H_2O band occurs at 1.92 μm for hisingerite that is broadened, similar to allophane (fig 2)

TIR Results : Al/Si-rich Smectites

- JB1489 exhibits a strong quartz signature in the doublet at 1212 cm^{-1} and 1078 cm^{-1}, but also shows features of opal that can be seen in the Si-O band at 476 cm^{-1} as well as in the VNIR data (fig 3)
- Loma Mar JB1487 and JB931 beidellite line up closely with the montmorillonite and beidellite spectra, respectively (fig 3)
- Stretching vibration bands can be seen at 1060 cm^{-1} and 1110 cm^{-1} for montmorillonite and opal, respectively, as well as Si-O bending bands near 450-600 cm^{-1} (fig 3)
- Loma Mar JB1486 spectra shows many features consistent with montmorillonite, higher Si content minerals such as opal, and carbonate features as seen in dolomite (fig 4)
- Differences between the JB1486 and JB1487 samples are due to the addition of opal and carbonate in the JB1486 rock (fig 4)

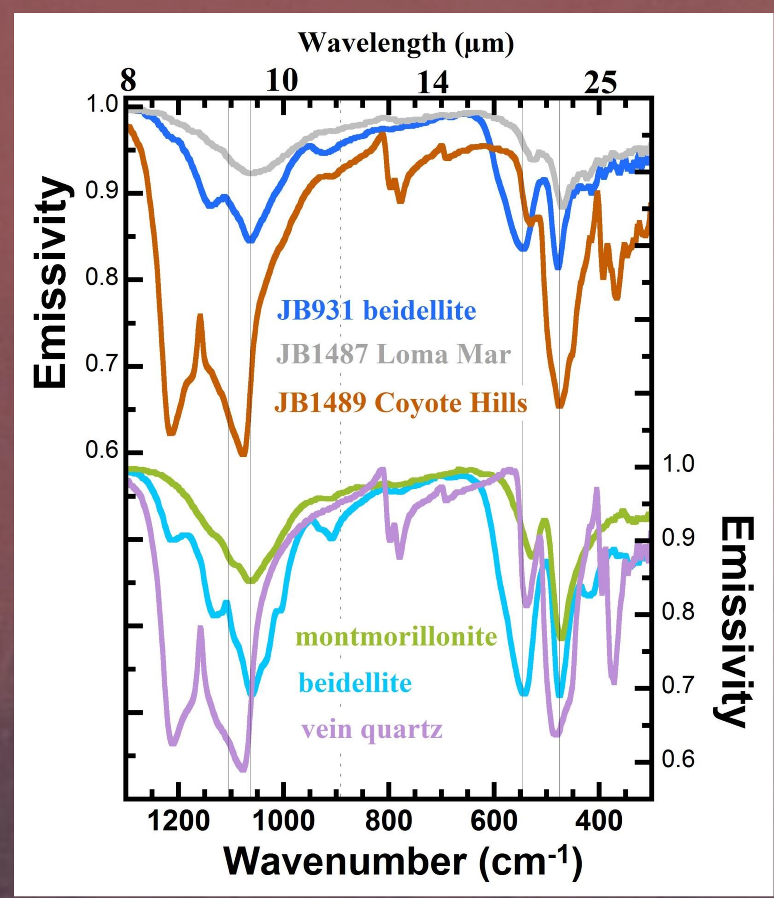

Figure 3. TIR Emissivity spectra of Al/Si-rich clay-bearing rocks compared with spectra of minerals.

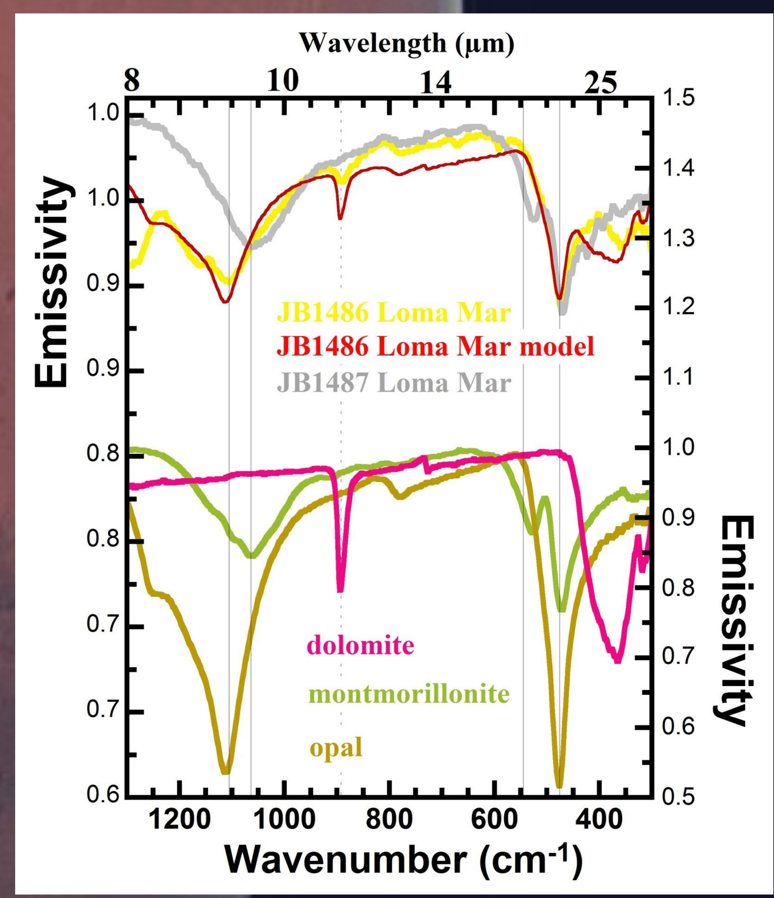

Figure 4. TIR Emissivity Spectra of Al-rich clay-bearing rocks and modeled data for JB1486 compared with spectra of pure Al-rich minerals.

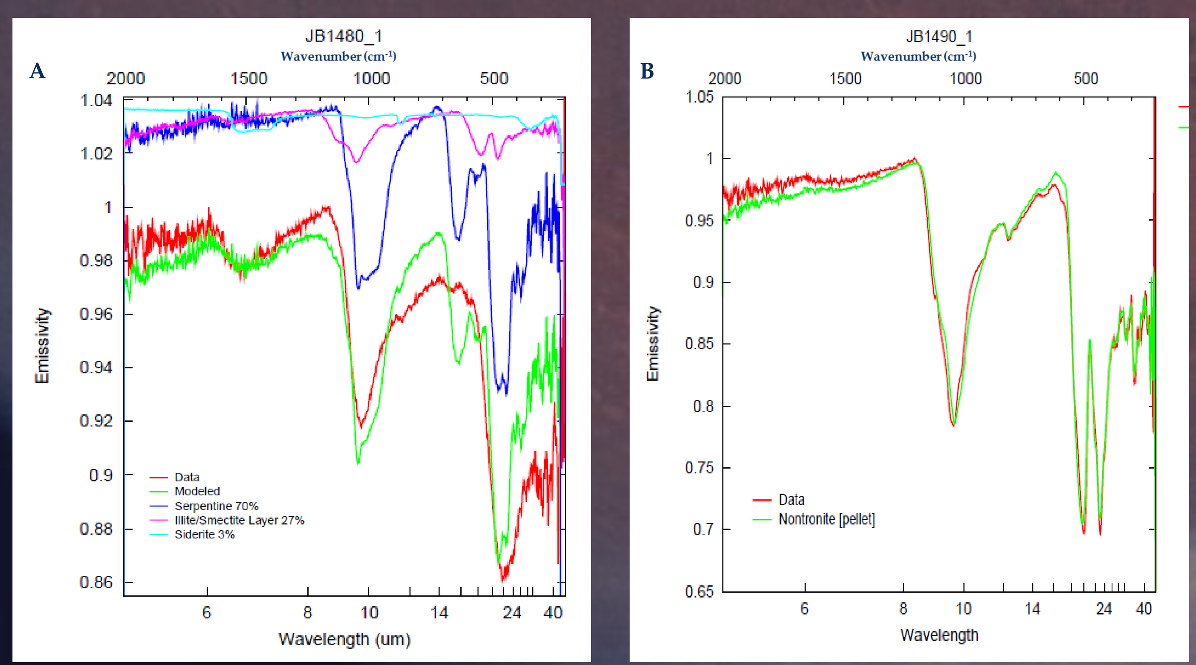

Figure 5A/B. Modeled TIR Emissivity Spectra for Fe-rich clay bearing rocks.

TIR Results : Fe-rich Smectites

- The hisingerite-bearing rock spectrum exhibits a single Si-O band near 480 cm^{-1} similar to the band observed for trioctahedral phyllosilicates [e.g. 10] (fig 5A)
- No hisingerite samples were available; so, the data was modeled with several clay minerals for best fit (fig 5A)
- Nontronite shows a strong dioctahedral phyllosilicate doublet signature near 470 cm^{-1} and 550 cm^{-1} (fig 5B)
- The nontronite sample in fig 5B is modeled well with a pure nontronite pellet spectrum from the ASU Spectral Library [10]

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