Comparing VNIR and TIR Spectra of Clay-Bearing Rocks

A. C. Davis¹,², J. L. Bishop¹,³, M. Veto⁴, S. Ruff⁴, T. Bristow³, W. Gates⁵, and D. Blake³

¹SETI Institute, Mountain View, CA, ²MiraCosta College, Oceanside, CA, ³NASA-Ames Research Center, Moffett Field, CA, ⁴School of Earth and Space Exploration, Arizona State University, Tempe, AZ, ⁵SmecTech Research Consulting, Moorabbin, Australia.

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].

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 in previous studies [3]. 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

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, 1.92 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)
• H₂O band occurs at 1.91 μm for nontronite (fig 2)
• H₂O bands occur 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 JB1483 beidelite line close 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 bonding 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)

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 with a pure nontronite pellet spectrum from the ASU Spectral Library [10]

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References


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

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Sample Name</th>
<th>XRD Results</th>
<th>Sample Info</th>
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<tbody>
<tr>
<td>JB931</td>
<td>Beidellite</td>
<td>smectite with ~5-10% quartz, white, waxy</td>
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<td>JB1480</td>
<td>Hisingerite</td>
<td>quartz, feldspar, chlorite, green, waxy</td>
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<tr>
<td>JB1489</td>
<td>Loma Mar</td>
<td>quartz, smectites</td>
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</tr>
<tr>
<td>JB1487</td>
<td>Nontronite</td>
<td>med-hard, lime green, chalky</td>
<td></td>
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