

NEAR INFRARED SPECTRAL ANALYSIS OF MIXTURES OF HALITE AND LABRADORITE FOR APPLICATION TO PUTATIVE CHLORIDE DEPOSITS OBSERVED BY CRISM. H. B. Jensen¹ and T. D. Glotch¹, ¹Department of Geosciences, 255 Earth and Space Sciences Building (ESS), Stony Brook University, Stony Brook, NY 11794-2100. heidijensensb@gmail.com

Introduction: Putative chloride salt deposits have been detected in Mars Odyssey THEMIS daytime infrared images. The mid-IR spectra of these deposits are characterized by an unusually high apparent emissivity in processed data at shorter wavelengths in comparison to surrounding units [1]. CRISM visible to near infrared (VNIR) FRT and HRL images covering these deposits also indicate the presence of this probable chloride salt based on a red spectral slope lacking distinctive absorptions throughout the 1-2.7 μ m range and a lack of the 3 μ m water absorption band in spectra ratioed to spectrally neutral material [2]. However, diffuse reflectance spectra of halite taken in the laboratory setting do not result in a red spectral slope in the near infrared [3]. We hypothesize that this red spectral slope is due to the mixing of chloride with a feldspar mineral such as labradorite, which is found on the Martian surface, and shows a slope in this region due to the Fe²⁺ absorption band centered at about 1.3 μ m [4].

Here we report on diffuse reflectance spectra of labradorite and halite mixtures. By investigating the effect of adding various amounts of labradorite to halite, we hope to find a suitable combination which allows for the red spectral slope viewed in the ratioed CRISM spectral data.

Methodology: CRISM data were investigated in areas where putative chloride deposits are observed in THEMIS daytime decorrelation stretched (DCS) images. We confirmed the unique spectral character of these deposits by extracting the atmospherically corrected THEMIS emissivity spectra from the images.

CRISM DCS images were made using CRISM multispectral summary products [1, 5]. To display phyllosilicates in association with the chloride deposits, red, green and blue were assigned to the reverse of the IR spectral slope parameter, D2300 (2.3 μ m drop off), and HCPINDEX (high calcium pyroxene) respectively. An example of this can be seen in Figure 1, where the putative chlorides appear to be red, phyllosilicates appear to be green and pyroxene appears to be blue.

Spectra were extracted from atmospherically corrected CRISM hyperspectral image cubes by averaging pixels over areas bearing chloride (red) and phyllosilicate (green). In order to remove any remnant atmospheric effects or instrumental errors, these spectra were then ratioed to regions in the image that were considered to be spectrally neutral. Generally dust is the desired spectra for conducting ratios, however the

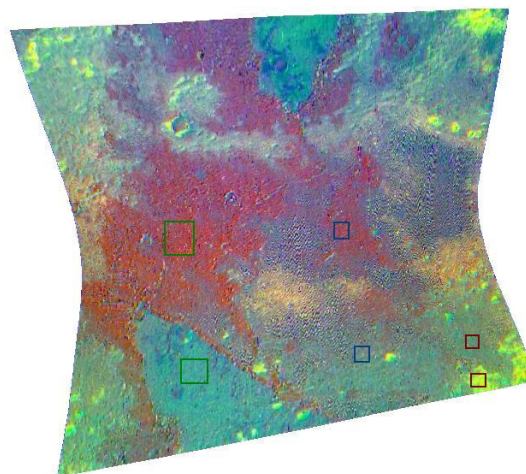


Figure 1. Projected CRISM image FRT0000A102_07 mapped where red, green and blue are chloride, phyllosilicate and pyroxene respectively. Boxes indicate pixels where spectra of glowing terrain and phyllosilicate have been averaged and the neutral region that is used in spectral ratios (Figure 2). Colors in this figure correspond with those in the ratioed CRISM spectra.

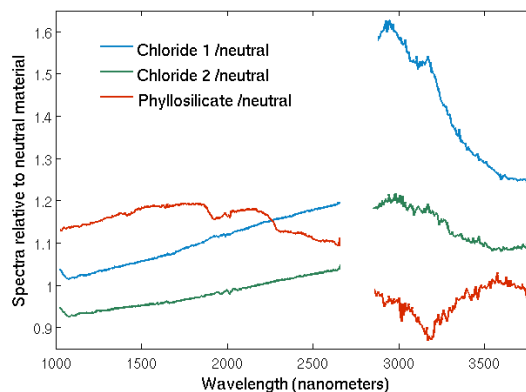


Figure 2. The CRISM spectra of 2 chloride-rich units and a phyllosilicate region ratioed against spectrally neutral regions in the image derived from FRT0000A102_07 (shown in Figure 1).

study regions were largely dust-free, so regions that were pyroxene-rich within the image were utilized.

Labradorite was mixed with reagent grade halite (99 %+) powder in proportions of 0, 10, 25, 50, 75, 90, and 100 (wt.) %. These mixtures were then ground with a mortar and pestle to achieve sample homogeneity and grain size uniformity. Pellets of these sample

mixtures were then prepared and stored in an oven at 80 °C for 3 days to remove water in the samples. The diffuse visible to near infrared reflectance of these pellets was then collected in the Laboratory for Infrared Spectroscopy (LIRS) at Stony Brook University, using the Nicolet 6700 FTIR spectrometer equipped with a diffuse reflectance attachment, a CaF₂ beamsplitter and an InGaAs detector. Spectral ratios were then made of halite-rich mixtures versus labradorite-rich mixtures to simulate the method in which CRISM spectra are ratioed.

Results and Discussion:

CRISM ratio spectra. Standard results from extracting and taking ratios of spectra from chloride-bearing and phyllosilicate-bearing regions can be seen in Figure 2. In comparison with the phyllosilicate-bearing unit, the chloride-bearing unit shows a lack of absorptions and an upward slope in the 1-2.7µm range and lacks the 3µm hydration band. This lack of an absorption in the 3µm region indicates that the chloride deposit is not only less hydrated than the proximate phyllosilicate unit, but also the pyroxene-rich area that is used as a neutral material in the spectral ratio. The lack of features in the 1-2.7µm region along with its degree of desiccation agrees well with anhydrous chlorides such as halite. However, the red slope in the CRISM data cannot be explained by the presence of halite alone.

Laboratory mixtures. Labradorite/halite mixture spectra can be seen in Figure 3. A ratio of halite-rich versus halite-poor laboratory diffuse reflectance spectrum can be seen in Figure 4.

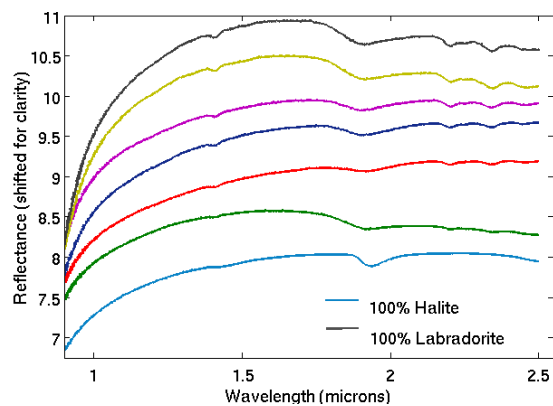


Figure 3. The spectra of 0, 10, 25, 50, 75, 90 and 100% mixtures of halite (bottom) and labradorite (top). Absorptions at 1.4 and 1.9µm are attributed to the presence of water in the samples. Absorptions associated with the labradorite sample can be easily seen starting at just 10 % (wt.) in the 2.2 to 2.4µm region.

Upon dividing a halite-rich mixture by a labradorite-rich mixture, the 2 labradorite absorptions in the

2.2 to 2.4µm range (likely due to a contaminant phases) disappear and only a featureless sloping spectrum remains. Absorptions in the laboratory spectra seen at 1.4 and 1.9µm can be associated with the persistent presence of water in the sample mixtures even after 3 days of storage at 80°C.

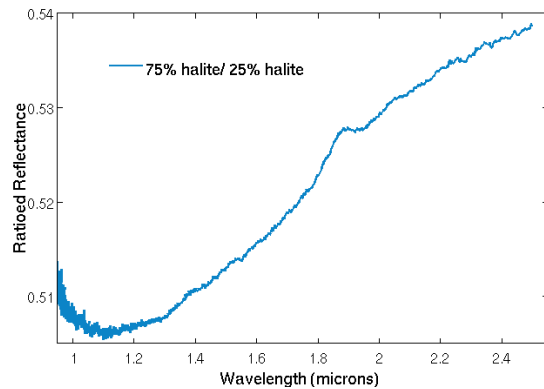


Figure 4. The spectral ratio of 75% halite versus 25% labradorite to reproduce the ratioing of CRISM spectra in Figure 2. The slight peaks at 1.4 and 1.9µm are attributed to the hydration of the sample. These proportions of halite were used because their ratio resulted in the smallest hydration interference.

Conclusions and Future work: Our results show that the CRISM ratioed spectra of putative chloride-bearing units can be replicated in the laboratory by ratioing mixtures of halite and labradorite. The lack of absorptions and sloping character in the 1-2.7µm region produced by ratioing of the laboratory mixtures supports the hypothesis that chloride salts are present on the Martian surface.

In future work, the samples will be thoroughly dried in a vacuum oven at 150 °C before being pressed into pellets. This should effectively remove the absorptions seen in the laboratory spectra attributed to water. We will also investigate the visible wavelength region to see if spectra of the mixtures of halite and labradorite can also match the CRISM spectral character observed in this wavelength region. In addition, chloride salts will be mixed with other materials such as basaltic sands and powders to more accurately represent the Martian surface composition and investigate grain size effects.

References: [1] Osterloo M. M. et al. (2008) *Science*, 319, 1651-1654. [2] Murchie S. L. et al. (2009) *J. Geophys. Res.*, 114, E00D06. [3] Crowley J. K. (1991) *J. Geophys. Res.*, 96, 16,231-16,240. [4] Adams J. B. and Goullaud L. H. (1978) *LPSC IX*, 2901-2909. [5] Pelkey S. M. et al. (2007) *J. Geophys. Res.*, 112, E08S14.