

SPECTROSCOPIC DETECTION LIMITS OF MINOR PHASES IN CHLORIDE-BEARING MINERAL MIXTURES. Cheng Ye¹ and Timothy D. Glotch¹, ¹Department of Geosciences, Stony Brook University, Stony Brook, NY, 11794-2100 (cheng.ye.1@stonybrook.edu).

Introduction: Chloride salt-bearing deposits in the southern highlands of Mars have been observed and characterized by both mid-infrared (MIR) and visible-to-near-infrared (VNIR) remote sensing instruments [1-3]. Laboratory VNIR spectral measurements of mixtures of anhydrous chloride salt and silicates generally reproduce the characteristic spectra seen in remote sensing measurements [4]. Laboratory MIR emissivity spectra of halite/basalt mixtures and hybrid T-matrix/Hapke light scattering models provide constraints on the abundances and particle sizes of salt in the Martian chloride deposits. Particle sizes between 63 and 180 μm and halite contents between 10 and 25 wt.% are consistent with the THEMIS data in regions with coarse particulate surfaces which show a concave up spectral shape. Particle sizes $<10 \mu\text{m}$ and abundances of 10 to 25 wt.% are required to match the THEMIS data with regional fine-particulate dust indicating a concave down spectral shape [5, 6].

Chlorides often form in evaporative environments, which display a variety of mineral assemblages, including chlorides, carbonates, and sulfates, etc. However no additional evaporite minerals have been identified in relation to chloride salt-bearing deposits on Mars. The goal of this work is to determine the detection limits of additional evaporite minerals in halite/silicate mixtures.

Sample Selection and Preparation: We obtained natural samples of halite, labradorite, calcite and gypsum from Ward's Natural Science. Samples were ground with a mortar and pestle and then dry sieved to several grain size fractions. We made halite/labradorite mixtures with 20 wt% halite in a 63-90 μm size fraction, based on constraints of abundance and particle sizes from Glotch et al (2016). A third component, either calcite or gypsum, was added to the mixtures starting with 0.1 wt% up to 20 wt%.

Laboratory Spectroscopic Measurements: We collected VNIR reflectance spectra of our samples using an ASD FieldSpec3 Max spectroradiometer and MIR emissivity spectra on a Nicolet 6700 FTIR spectrometer at Stony Brook University's Center for Planetary Exploration (CPEX).

Results:

Detection limit of calcite in halite/labradorite mixtures.

At VNIR wavelengths (Figure 1a), the halite/labradorite mixtures show a broad absorption band at about 1.35 μm due to Fe^{2+} in labradorite, a 1.9 μm

hydration feature associated with the water in the sample, and 2.2 μm , 2.3 μm bands likely caused by small amounts of contaminants in the labradorite. The overall reflectance spectral shape has no substantial change with calcite content below 1 wt%. With the addition of more calcite, 2.35 μm and 2.5 μm absorption bands associated with calcite becomes more significant when the calcite abundance gets to 5 wt%.

At MIR wavelengths (Figure 1b), the halite/labradorite mixtures shows the silicate band at 1200~800 cm^{-1} range, and the Christiansen feature at $\sim 1260 \text{cm}^{-1}$. A band centered at $\sim 1530 \text{cm}^{-1}$ appears gradually with the increase of calcite abundance in halite/labradorite mixtures, which is related to the asymmetric stretch of the CO_3^{2-} ion in the mineral structure. When the content of calcite gets 10 wt%, another small band at about 1760 cm^{-1} appears.

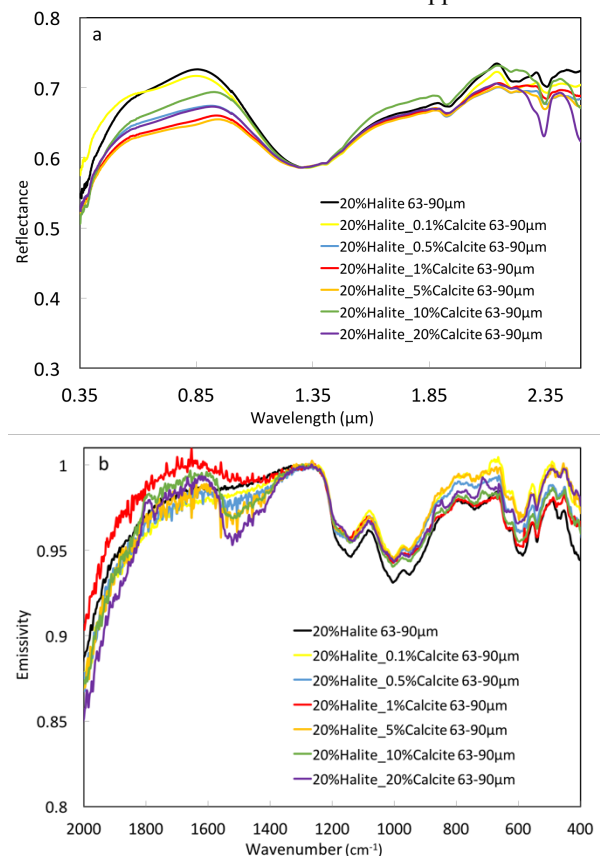


Figure 1. Laboratory VNIR reflectance and MIR emissivity spectra of halite/labradorite and calcite mixtures. Reflectance spectra are scaled to have the same reflectance at $\sim 1.3 \mu\text{m}$ to clear the spectral change.

Detection limit of gypsum in halite/labradorite mixtures.

In VNIR reflectance spectra (Figure 2a), the absorption bands 1.4, 1.9, 2.5 μm associated with gypsum can be detected when 1 wt% gypsum is present in the halite/labradorite mixtures. Another two weak absorption bands around 1.7 and 2.1 μm can be seen when 5 wt% gypsum in the halite/labradorite mixtures.

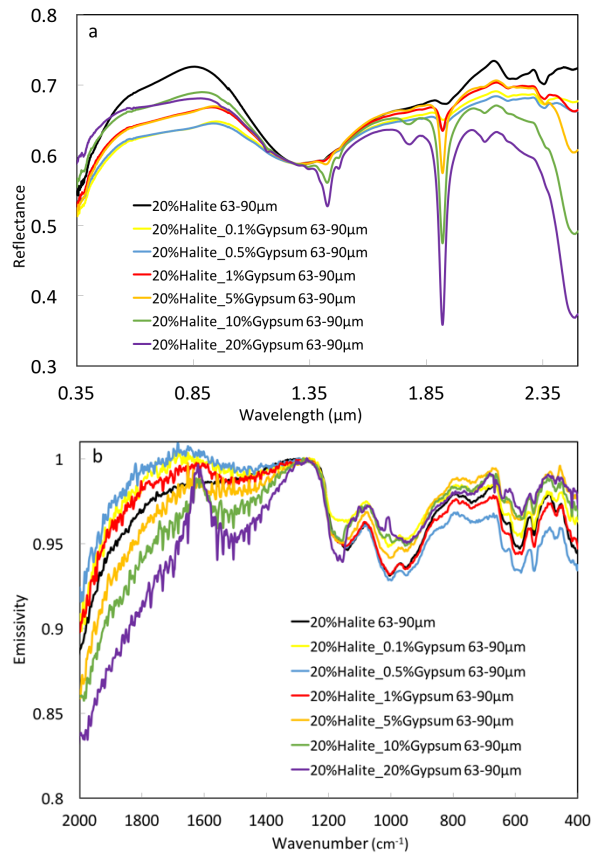


Figure 2. Laboratory VNIR reflectance and MIR emissivity spectra of halite/labradorite and gypsum mixtures. Reflectance spectra are scaled to have the same reflectance at $\sim 1.3 \mu\text{m}$ to clear the spectral change.

In MIR emissivity spectra (Figure 2b), a band around 1500 cm^{-1} shows when 1 wt% gypsum present in the halite/labradorite and becomes more and more prominent with the increasing of gypsum abundance. The main vibrational band of gypsum at 1160 cm^{-1} appears at a gypsum abundance of ~ 10 wt% in mixtures.

Discussion: Our laboratory spectral measurements show that calcite and gypsum can't be detected in halite/labradorite mixtures at abundances below 1-5 wt% in the 63-90 μm size fraction. The apparent absorption bands associated with calcite and gypsum are easily detectable when their abundances are higher than 5 wt%.

In the future, we will add other grain size fractions constrained by former research and other evaporate minerals and/or chemical weathering products with different abundance to determine their detection limits in halite/silicate mixtures. We will also use several quantitative scattering models to predict the spectra and then compare with the laboratory data.

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References: [1] Osterloo, M. M. et al. (2008) Science, 319, 1651-1654. [2] Osterloo, M. M. et al. (2010) JGR, 115, E10012. [3] Murchie, S. L. et al. (2009), J. Geophys. Res., 114, E00D06. [4] Jensen, H. B., and T. D. Glotch (2011), J. Geophys. Res., 116, E00J03. [5] Glotch, T. D. et al. (2010), Geophys. Res. Lett., 37, L16202. [6] Glotch, T. D. (2016) JGR, Planets, 121, 454-471.