

DEHYDRATION-REHYDRATION EXPERIMENTS WITH CL SALTS MIXED INTO MARS ANALOG MATERIALS AND THE EFFECTS ON THEIR VNIR SPECTRAL PROPERTIES.

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Summary: Chloride (Cl) bearing salts are found on Mars both as components of the regolith and as pure deposits [1-3]. Recently, they were also proposed as an explanation for recurring slope lineae [4]. Many of these salts can rapidly exchange water with the environment through deliquescence/efflorescence, and some can store molecules in their structure as water of hydration. Characterizing the spectral properties of mixtures of Cl salts in Mars analog materials would therefore assist in their detection with remote sensing instruments, and also in understanding how H₂O interacts between the Cl salts and the regolith particles.

Experiments were designed with three Cl salts and three Mars analog materials under different moisture conditions. Experiments with 10 wt.% Cl salts mixed with these analog materials revealed changes in the spectral properties of the salts as they hydrated. Changes in the spectral features of CaCl₂ included shifts in absorption bands from 1.99 to 1.96 μm and from 2.11 to 2.19 μm. These are interpreted as related to water features in CaCl₂/soil mixtures due to water molecules being adsorbed from room air. Based on these experiments, it may be possible to detect temporal changes in the spectral features of Cl salts on Mars due to H₂O exchange with the atmosphere or the regolith as a result of diurnal or seasonal changes in moisture levels.

Methods: Three Mars analog materials were dry sieved to <250 μm for this study. These samples include the Mojave Mars Simulant (MMS, [5]), altered volcanic ash MK 91-16 from Mauna Kea [6], and altered volcanic ash Hal JB399 from Haleakala [7]. Hydrated Fe²⁺ perchlorate and hydrated Mg perchlorate were dehydrated in an oven at 100 °C prior to preparing the mixtures in order to remove excess water and enhance the bands near 2.16 μm (Fig.1). The CaCl₂ flakes obtained for this study were ground and dry sieved to <250 μm. The spectrum of this sample contains a strong band at 2.11 μm (Fig. 1). 10 wt.% mixtures were prepared with each of the 3 Cl salts and the 3 analog samples. Spectral analyses of these mixtures showed that the spectral features due to H₂O were changing with time. For the perchlorate-bearing samples the bands grew broader and the longer wavelength portion of the spectrum became saturated. For the chloride-bearing samples the bands near 1.99 and 2.11 μm shifted position. Spectra were acquired on all samples in black Teflon dishes using an ASD FieldSpecPro reflectance spectrometer from 0.35 to 2.5 μm under ambient lab conditions.

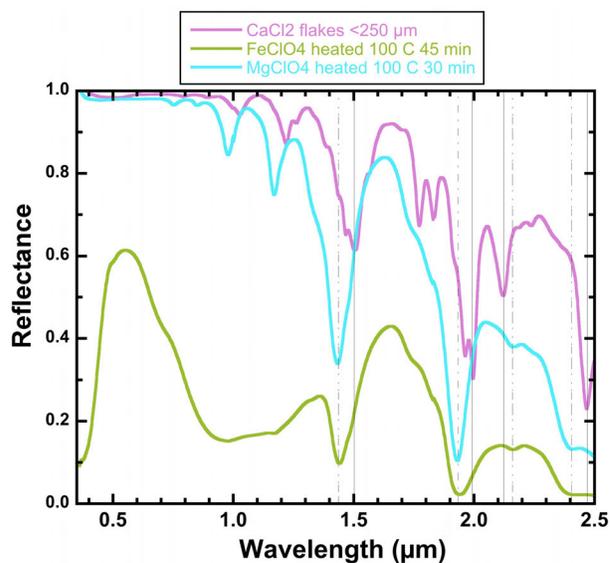


Fig. 1 VNIR reflectance spectra of Cl salts used in the mixtures. These spectra are similar to those reported for chlorides and perchlorates recently [8-10]. These 3 Cl salts were selected because of their bands at 2.11-2.16 μm to coordinate with observations in [4].

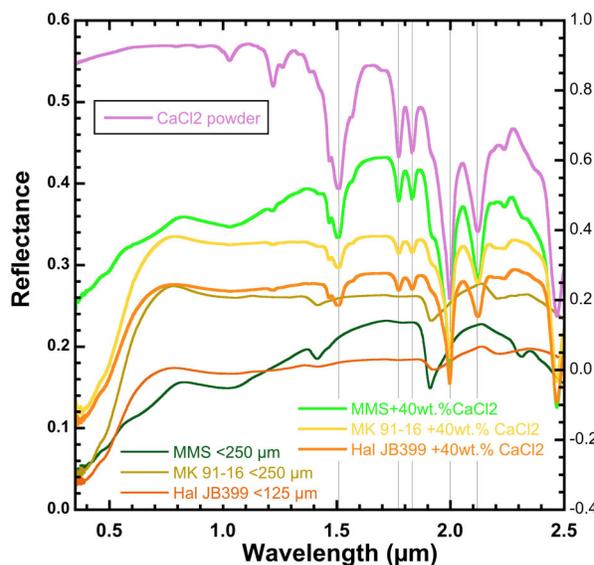


Fig. 2 VNIR reflectance spectra of mixtures of 40 wt.% CaCl₂ in 3 Mars analog samples and the mixture endmembers. The spectra were measured prior to hydration of the samples.

In order to better understand the nature of Cl salts in a Mars regolith matrix, mixtures were prepared with

40 wt.% CaCl₂. These mixture samples and the pure CaCl₂ sample were dehydrated at 85 °C and then spectra were run at short intervals as the samples hydrated in lab air. Selected spectra from each of these experiments are shown in Figs. 3-5. In all cases the characteristic bands of CaCl₂ at 1.99 and 2.11 μm shifted to 1.96 and 2.19 μm upon hydration. This was observed for the pure CaCl₂ sample as well as the mixtures. The relative intensity of the doublet at 1.78 and 1.84 μm also changed as the samples hydrated.

We also noticed that the CaCl₂ salt hydrated faster in the altered Mauna Kea and Haleakala ash samples than in the Mojave soil. This could be due to differences in grain size and abundances of adsorbed water in the samples. Although all three analog materials were dry sieved to <250 μm prior to the experiments,

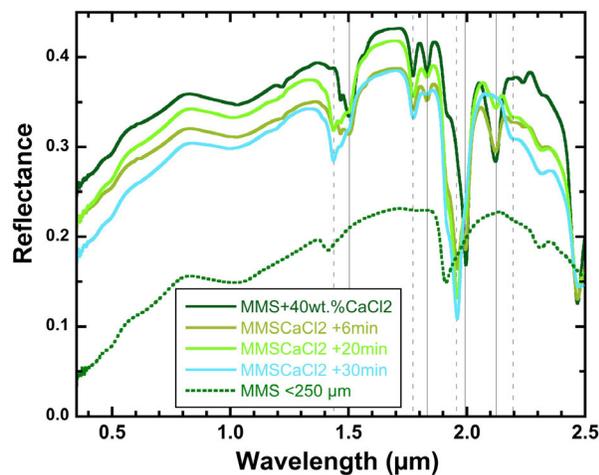


Fig. 3 VNIR spectra of CaCl₂ in the MMS analog upon hydration in lab air. MMS endmember in dotted line.

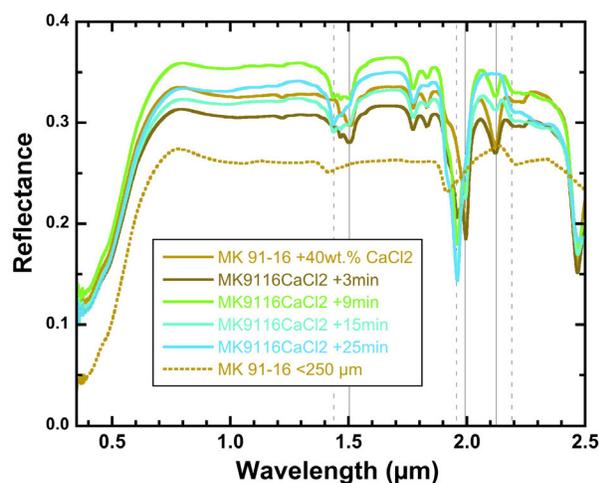


Fig. 4 VNIR spectra of CaCl₂ in MK 91-16 analog upon hydration in lab air. MK 91-16 endmember in dotted line.

the MK 91-16 and Hal JB399 samples contain larger fractions of fines. A recent mixture study showed that the MK 91-16 sample was dominated by fines, and that abundant particles <5 μm diameter were still present after wet sieving to <63 μm in methonal [6].

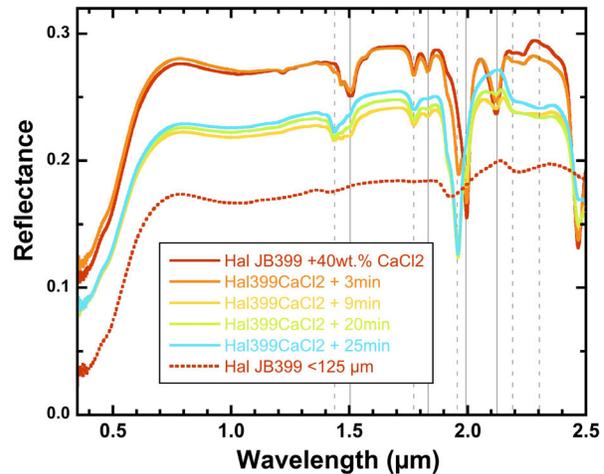


Fig. 5 VNIR spectra of CaCl₂ in Hal JB399 analog upon hydration in lab air. Hal JB399 endmember in dotted line.

Conclusions: These experiments illustrate the dynamic nature of Cl-bearing salts even as components of a soil or regolith. Changes in the abundance of H₂O in the sample were reflected in the NIR spectral properties and these appeared to be reversible in our experiments. H₂O in these soil samples may be getting extracted by the Cl salts. These experiments indicate that H₂O adsorption and desorption occurs quickly in Mars analog soils containing Cl salts. This is expected to occur on Mars as well, though at a slower rate due to the colder and drier conditions. In fact, it may be possible to detect diurnal or seasonal changes in moisture levels on Mars by monitoring the spectral features of Cl salts in the regolith.

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