

Laboratory measurements of carbonate–phyllosilicate mixtures

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Abstract

The spectral identification of mineral deposits on Mars is related to laboratory data of minerals and their mixtures. The aim of this work is to provide reflectance spectra of some mixtures of carbonates and phyllosilicates in the wavelength range from visible (VIS) to mid-infrared (MIR). Remote sensing data collected by the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) have indicated the presence of such minerals in several locations dated in Noachian Era. Since carbonates and phyllosilicates are mostly detected using their absorptions, partially overlapped, in the 0.4–2.6 μm range, we have investigated for which relative weight percentage it is possible to spectrally distinguish these minerals.

1. Introduction

The carbonate deposits found on Mars [1, 2], including several craters such as Gusev [3] and Leighton [4], are closely associated with phyllosilicate-bearing rock units and probably formed during the Noachian or early Hesperian era from the alteration of these rocks by either hydrothermal fluids or near-surface water [5, 6, 7].

Carbonates are widely identified in CRISM data by the two absorption features located at 2.3 and 2.5 μm . Their spectra are also characterized by two broad bands located at about 3.4 μm and 3.9 μm . Since these latter two features are difficult to observe in CRISM spectra, the confirmation of the carbonate assignment to a putative sediment deposit on Mars has been done on the basis of the identification of the bands located in the wavelength range up to 2.6 μm . On the other hand, also phyllosilicates show absorption features in the same spectral range, and, due to the fact that their shape are broader than those of carbonates, it could be difficult to distinguish both phases in a spectrum of their mixture.

The objective of this work is to assess a detection limit

for carbonate concentration in a mixture with phyllosilicate through the analysis of laboratory spectra.

2. Spectral measurements

We have focused our attention on three binary mixtures of carbonates and phyllosilicates (i.e. calcite–kaolinite, magnesite–nontronite, siderite–nontronite). We have divided each powdered mineral in two dimensional classes $<106 \mu\text{m}$ and $>200 \mu\text{m}$, conventionally called fine and coarse, respectively, using both granulometry in the examined mixtures.

We have started to mix 50 wt% of each mineral and then we have changed gradually the relative amount of each component until, in the spectrum, the absorptions characterizing both minerals were clearly visible or, viceversa, when one of them was not spectrally identifiable.

Hemispherical reflectance spectra of mixtures were measured by meaning of two spectrometers: *Perkin Elmer Lambda 900* and *Perkin Elmer Spectrum 2000* coupled with two integrating spheres. An example of the obtained spectra is shown in Figure 1.

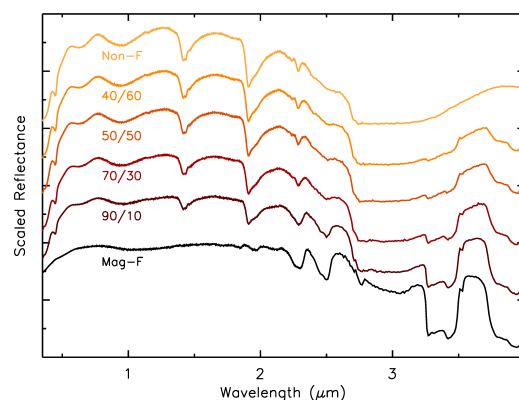


Figure 1: Reflectance spectra of magnesite, nontronite and their mixtures.

3. Spectral analysis

In order to assess the detection of carbonates in our laboratory mixtures, we have used the spectral parameter defined in [8, 9] for the analysis of CRISM spectra. In particular, we have applied to the spectra the BDCARB for carbonates and BD1900 for phyllosilicates. In order to compare consistently such parameters, we have normalized them setting the minimum value to 0 and the maximum value to 1. An example of the obtained results is given in Figure 2.

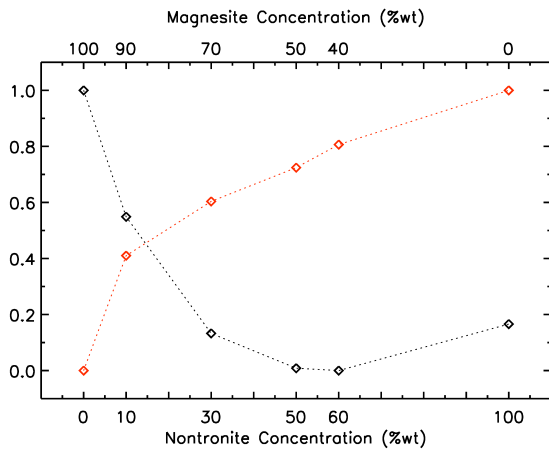


Figure 2: Trend of the BD1900 (red diamonds) and BDCARB (black diamonds) for different concentrations of a magnesite and nontronite mixture.

4. Conclusions

The application of spectral parameters characterizing a particular mineral could be useful in the analysis of a laboratory mixture allowing to assess a detection limit for each of the minerals in the mixture.

As shown in Figure 2, the crossing point of the two lines divides the plot in two parts: the left side dominated by the carbonate and the right one by the phyllosilicate. This occurrence could be a good starting point for assessing the detection limit of less visible minerals such as carbonates in the example shown here and this could be of some help in the interpretation of mineral maps of the martian surface.

References

[1] Ehlmann, B. L. et al.: Clay minerals in delta deposits and organic preservation potential on Mars, *Nature Geoscience*, Vol. 1, pp. 355–358, 2008.

[2] Boynton, W. V. et al.: Evidence for calcium carbonate at the Mars Phoenix landing site, *Science*, Vol. 325, pp. 61–64, 2009.

[3] Morris, R. V.: Identification of carbonate-rich outcrops on Mars by the Spirit rover, *Science*, Vol. 329, pp. 421–424, 2010.

[4] Michalski, J. R. and Niles, P. B.: Deep crustal carbonate rocks exposed by meteor impact on Mars, *Nature Geoscience*, Vol. 3, pp. 751–755, 2010.

[5] Fassett, C. I. and Head, J. W.: Valley network-fed, open-basin lakes on Mars: Distribution and implications for Noachian surface and subsurface hydrology, *Icarus*, Vol. 198, pp. 37–56, 2008.

[6] Marzo, G. A. et al.: Evidence for Hesperian impact-induced hydrothermalism on Mars, *Icarus*, Vol. 208, pp. 667–683, 2010.

[7] Andrews-Hanna, J. C. et al.: Early Mars hydrology: Meridiani playa deposits and the sedimentary record of Arabia Terra, *Journal of Geophysical Research*, Vol. 115, E6, 2010.

[8] Pelkey, S. M. et al.: CRISM multispectral summary products: Parameterizing mineral diversity on Mars from reflectance, *Journal of Geophysical Research*, Vol. 112, E8, 2007.

[9] Ehlmann, B. L. et al.: Identification of hydrated silicate minerals on Mars using MRO-CRISM: Geologic context near Nili Fossae and implications for aqueous alteration, *Journal of Geophysical Research*, Vol. 114, E2, 2009.