

**DIFFUSE REFLECTANCE SPECTRA OF MONOHYDROCALCITE.** S. Smyth<sup>1\*</sup>, D. M. Applin<sup>1</sup>, M. R. M. Izawa<sup>1</sup>, and E. A. Cloutis<sup>1</sup>. <sup>1</sup>Hyperspectral Optical Sensing for Extraterrestrial Reconnaissance Laboratory, Department of Geography, University of Winnipeg, 515 Portage Ave., Winnipeg, Manitoba, Canada, R3B 2E9. \*smyths@webmail.uwinnipeg.ca.

**Introduction:** Monohydrocalcite ( $\text{CaCO}_3 \cdot \text{H}_2\text{O}$ ) is a comparatively rare carbonate phase, but is important in a wide range of geochemical and biogeochemical systems including the decomposition of ikaite ( $\text{CaCO}_3 \cdot 6\text{H}_2\text{O}$ ), in lacustrine and spring-fed deposits, as a component of 'moonmilk' in caves, as direct bioprecipitates, and as a breakdown product of Ca-oxalates during decomposition [1-4]. Notably, monohydrocalcite is compositionally identical and probably structurally related to amorphous calcium carbonate (ACC) [2,5], and both monohydrocalcite and ACC are important metastable precursors to other Ca-carbonate phases. Many occurrences of monohydrocalcite are directly or indirectly influenced by biological activity. Hydrated carbonates, possibly including monohydrocalcite, may be present on the martian surface [e.g., 6, and see abstract #1881 by Applin et al., this meeting]. Monohydrocalcite may therefore play an important role in the (bio)geochemical cycle of carbon on Mars, and may act as a reservoir of carbonate and a potential carrier of traces of biological activity.

**Methods:** Naturally occurring monohydrocalcite from Lake Butler and Lake Fellmongery in Australia, aragonite, and a synthetic calcite have been analyzed by reflectance spectroscopy (<45  $\mu\text{m}$  fractions), atomic absorption/emission, ICP-MS, wet chemistry, and X-ray diffraction. Reflectance spectra were measured at the NASA-supported RELAB facility at Brown University. Spectra were measured from 300-26000 nm relative to halon (300-2600 nm; 5 nm spectral resolution;  $i=30^\circ$ ,  $e=0^\circ$ ) and brushed gold (2500-26000 nm; 4  $\text{cm}^{-1}$  spectral resolution;  $i=30^\circ$  and  $e=30^\circ$ ).

The near-infrared spectra were processed using a straight line continuum removal procedure to enable comparison of the band centers between samples.

**Results and discussion:** The reflectance spectra of monohydrocalcite is compared with those of calcite and aragonite in Figures 1-4.

Fig. 1 shows the overall spectrum of these three carbonates from 1000 to 16000 nm. In general, over the broad spectrum, it appears that monohydrocalcite exhibits reflectance much more similar to aragonite than calcite, especially longwards of  $\sim 5000$  nm. Monohydrocalcite and aragonite appear to be spectrally distinct from calcite in the  $\sim 6000$  nm region.

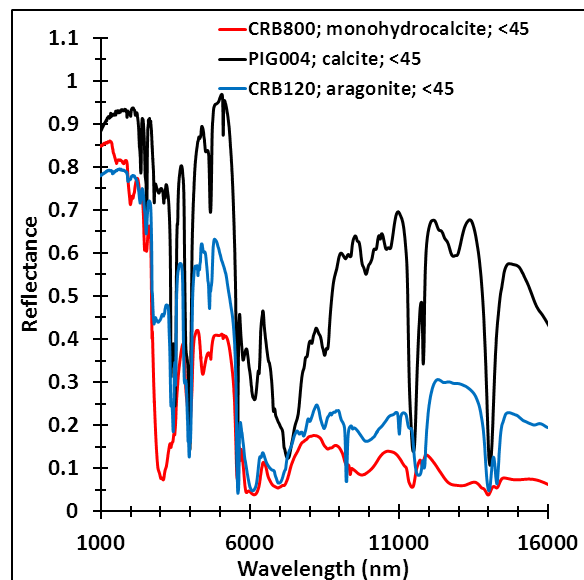
Fig. 2 shows the continuum-removed reflectance of diagnostic carbonate absorption bands in the second overtone region. Monohydrocalcite appears to be more spectrally similar to aragonite in these region in terms

of 2.3:2.5  $\mu\text{m}$  band depth ratio. However, the asymmetric splitting of the 2.5  $\mu\text{m}$  band is different, where the much stronger absorption occurs about 55 nm shorter than that of calcite.

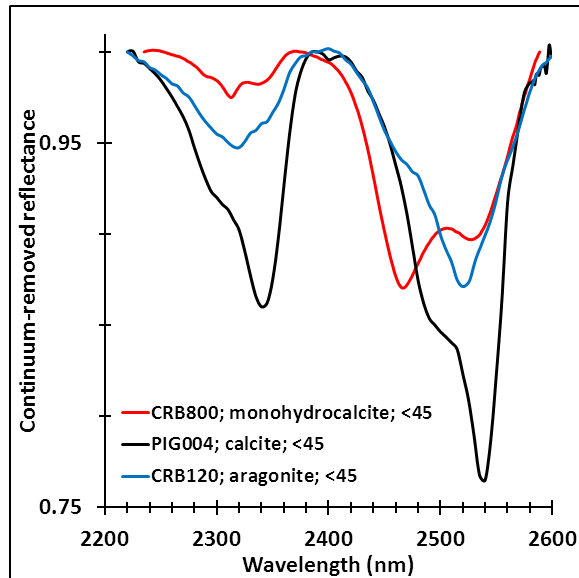
Fig. 3 shows the continuum-removed reflectance of diagnostic carbonate absorption bands in 3500 nm region. Monohydrocalcite exhibits distinct but similar spectra from aragonite and calcite in this region, with band minima at  $\sim 3.41$  and 3.47  $\mu\text{m}$ , and a near identical absorption relative to calcite at 3.97  $\mu\text{m}$ .

Fig. 4 shows fundamental carbonate absorption bands attributed to CO in-plane and out-of-plane bending modes. In this region, the monohydrocalcite appears to be spectrally similar to calcite (yet distinct), but quite different than aragonite. The band minima exhibited by monohydrocalcite are 40 and 20 nm shorter than calcite.

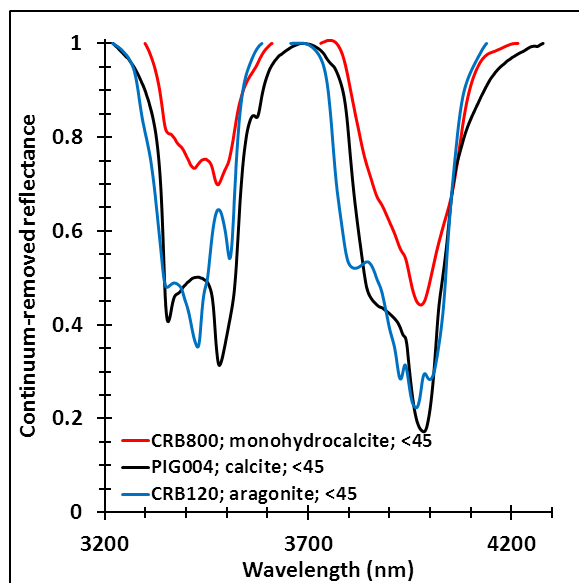
**Implications for Mars:** Here we present a comparison and contrast of the spectral reflectance exhibited by monohydrocalcite relative to the similar anhydrous phases of calcite and aragonite. Although there are many similarities to both phases, monohydrocalcite is spectrally distinct and should be discernable in remotely sensed data. Of particular interest is the contrast in the 2.5  $\mu\text{m}$  region, suggesting use of this region to discriminate it from other carbonates.



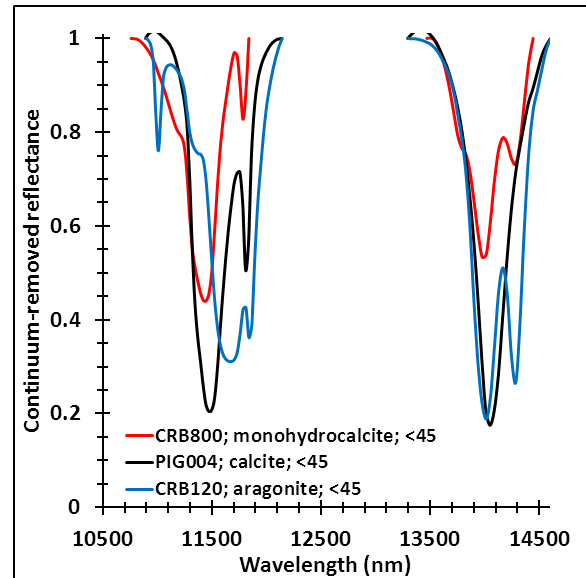
**Figure 1.** Diffuse reflectance spectra of monohydrocalcite and calcite.



**Figure 2.** Continuum-removed reflectance spectra of the diagnostic carbonate features in the second overtone region.



**Figure 3.** Continuum-removed reflectance of diagnostic carbonate features in the first overtone region.



**Figure 4.** Continuum-removed reflectance of diagnostic carbonate features in the fundamental absorption band region due to carbonate in-plane (~14000 nm) and out-of-plane bending (~11500 nm).

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