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An infrared spectroscopy study of impact shocked carbonates and implications for Mars

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► **To cite this version:**

Lu Pan, Bethany L Ehlmann, Paul D Asimow, Jinping Hu, Rebecca N Greenberger. An infrared spectroscopy study of impact shocked carbonates and implications for Mars. 49th Lunar and Planetary Science Conference, Mar 2018, The Woodlands, TX., United States. hal-02284117

HAL Id: hal-02284117

<https://univ-lyon1.hal.science/hal-02284117>

Submitted on 11 Sep 2019

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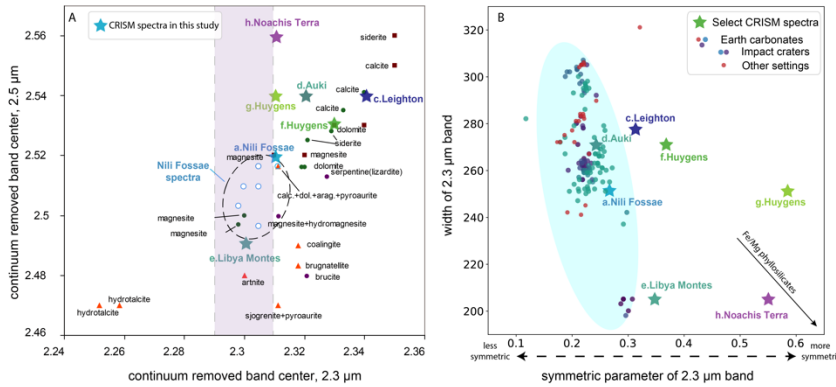


Figure 2: Scatter plot of spectral parameters for Mars data and measurement of terrestrial samples. A) Continuum removed band center of 2.3 and 2.5 μm absorptions (purple area shows the possible range of Fe/Mg phyllosilicate detections); B) Width of 2.3 μm band plotted against the symmetric parameter of the same band calculated as from the following equation: $sym2300 = (\lambda_{right\ shoulder} - \lambda_{band\ center}) / (\lambda_{band\ center} - \lambda_{left\ shoulder})$, so that $sym2300 = 1$ when the band is perfectly symmetric.

2A). We also observe a rather symmetric behavior of the 2.3 μm band in Mars data compared to terrestrial carbonates (Fig. 2B). Both these features are consistent with an effect of mixing with a different endmember, likely Fe/Mg phyllosilicate, which is widespread on Mars [3].

IR spectra of experimentally shocked carbonates.
 Near-infrared spectra of the natural magnesite sample before and after the shock recovery experiments show typical C-O bands at 2.316 and 2.515 μm and absorptions due to H₂O and OH in the structure at 1.415 μm and 1.914 μm, the latter forming a doublet with an associated C-O band at 1.968 μm (Fig. 3). The shape of C-O bands remains unchanged, but their strength decreases by 33% after ~10 GPa shock. Both the 1.415 and 1.914 μm absorptions become wider, presumably due to the increase of adsorbed, hydrogen-bonded water molecules relative to structurally bound H₂O. Weak combination absorptions in the carbonates at 1.866

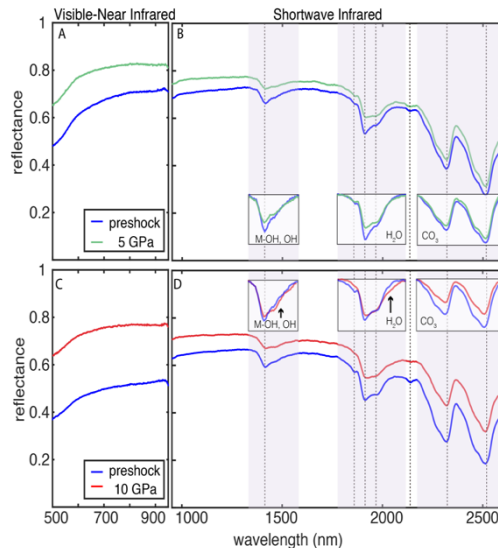


Figure 3: Spectra of magnesite from imaging spectrometer with VNIR and SWIR detectors, before and after shock recovery experiments. A-B) Spectra of Sample A, shocked to ~5 GPa, and C-D) Spectra of Sample B, shocked to ~10 GPa. Zoom windows show the continuum-removed spectra of relevant bands.

and 2.136 μm are present before the shock and are unchanged at 5 GPa but weakened after the 10 GPa shock. These results suggest that relevant shock pressures induce minor changes associated with structural water in magnesite, but the main CO₃ absorptions persist, exhibiting only minor decrease in band depth at ~10 GPa shock pressure.

Summary and implications: We find absorption features of carbonate are similar in both terrestrial sedimentary carbonate and carbonates in impact structures. Compared to these terrestrial carbonates, Martian spectral detections have more symmetric 2.3 μm bands, consistent with higher clay fractions in the >400 m² footprints of the Mars spectra, unlike the relatively clean carbonate rocks selected to represent Earth. We also observe some weakening of CO₃ bands and broadening of H₂O bands in experimentally shocked samples at ~10 GPa, but the CO₃ bands remain the strongest absorptions in rocks from terrestrial impact craters and impact experiments. Since impacts up to 10 GPa did not alter the carbonate signature significantly, the observed distribution of carbonates may be largely representative of their true distribution on Mars, unless other geologic processes (e.g. burial, volcanic activity, higher shock pressure) masked or altered the spectral signature of carbonates.

Acknowledgements: The authors thank G. Osinski, H. Newsom, G. Pösges, and D. Quinn for kindly offering their terrestrial carbonate collections; and J. Wray for sharing his CRISM spectra. The author also thanks G. R. Rossman, C. Ma, and F. Wu for their discussion and assistance.

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