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Water ice patches in Richardson crater, Mars

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Abstract

Based on CRISM and HiRISE data of Richardson crater (72°S, 179°E) we analyzed the seasonal evolution of ices in the dark dune spots [1], and found that water ice occurs inside them during the retreat of the seasonal cap. Liquid water has been hypothesized [2] to explain the flow like features about 10-100 meters from the dark dune spots, but here we did not find conclusive evidence in the spectral data.

1. Introduction

The spots are composed of three main units: dark core, gray ring and bright halo (Fig. 1.), which were analyzed during the period between LS 175° - 341°.

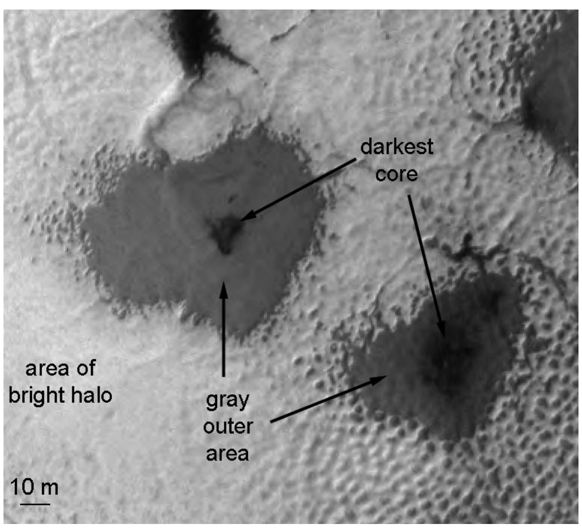

Fig. 1. Units of a spot: core, gray ring, bright halo

2. Methods

CRISM spectral data using FRT observations were analyzed between 1 and 4 µm, and corrected for photometry and atmospheric gas absorptions [3].. These were complemented by the analysis of HiRISE images to study the thickness of surface features using shadows. Spatial and temporal distributions of H_2O and CO_2 ice are analyzed the classical CRISM spectral indexes "BD1500", "BD 1430", and "ICER1" [4, 5]. Spectral unmixing was used to assess the relative contribution of different surface endmembers (CO_2 ice, water ice with different grain size) to observed spectra. We applied sparse linear unmixing using the Fully Constraint Least Square method. Results from the data analysis were compared to climate modeling predictions: the LMD GCM [6] combined with a local energy balance code has been used to predict the formation of ices on a given localized site with specific properties.

2. Results

Each unit of the spots show characteristic changes as the season progress, and based on the areal distribution, H_2O ice could be identified on the surface inside them (Fig. 2.).

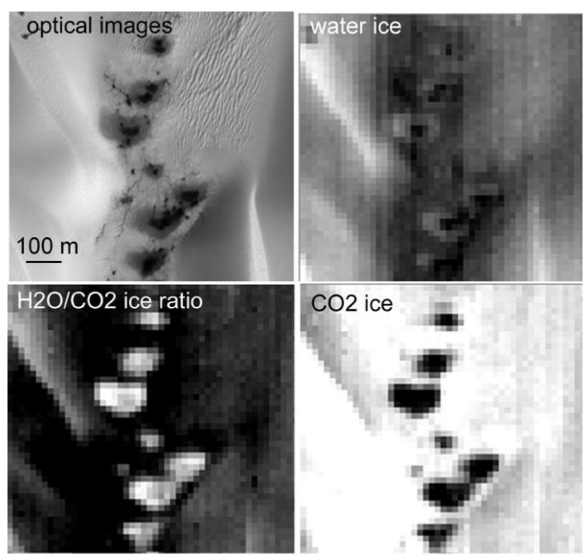

Fig. 2. Distribution of H_2O and CO_2 ice. From top left: 1. optical images (PSP_00307_1080), water ice band depth image (BD1500), ratio of H_2O/CO_2 ice (inverted ICER1), and CO_2 ice band depth images (BD1430). Bright water ice rings suggests surface bond H_2O ice in the gray ring unit.

Regarding the seasonal evolution, in winter the whole area is covered by CO_2 ice with large grain size (10 cm) with H_2O ice contamination. Dark spots form in late winter and early spring. In spring, they are located in a 10 cm deep depression compared to the surrounding bright ice layer. They are spectrally characterized by weak CO_2 ice signatures that probably result from spatial mixing of CO_2 ice rich and ice free regions within pixels, and from mixing of surface signatures due to aerosols scattering. The bright halo shaped by winds shows stronger CO_2 absorptions than the average ice covered terrain, and formed probably by CO_2 re-condensation.

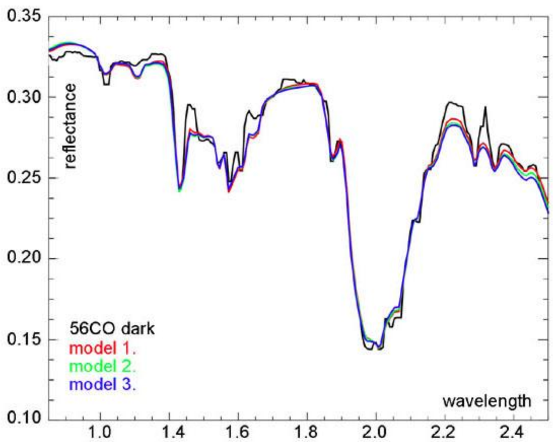

Fig. 3. Example spectra of the grey ring feature: observed (black, 56CO image) and modeled (colored) by FCLS algorithm. Models: 1.: inversion no gypsum, no liquid water, 2.: inversion with 1.46% liquid water no gypsum, 3.: inversion with 0.04% liquid water and 1.57% gypsum.

3. Formation models

According to spectral, morphological and modeling considerations, the gray ring is composed of a few tens of µm thin layer of water ice with 1-100 µm rain size (Fig. 3.). Two sources/processes could participate to the enrichment of water ice here: (i) H_2O condensation and precipitation at the surface in fall (prior to the condensation of the winter CO_2) or during winter time (by cold trapping of the CO_2, but later separated and left behind by the sublimating CO_2); (ii) ejection of dust grains surrounded by water ice by geyser activity [7]. Water ice remains longer in the gray ring unit after the complete sublimation of the CO_2. Finally, we also looked for liquid water in the near-IR CRISM spectra using linear unmixing modeling (Fig. 4.) but found no conclusive evidence for it.

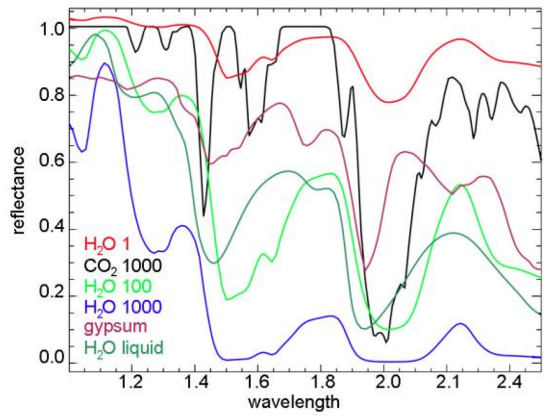

Fig. 4. Reference spectra used by FCLS to estimate the relative abundances for CRISM spectra. These spectra will be soon available at http://ghosst.obs.ujf-grenoble.fr.

4. Outlook

The results have important consequences: 1. During the observations the temperature was between 160-220 K measured at 3x8 km spatial resolution. Because of the grey ring's low albedo, warmer could be there, that may produce liquid interfacial water [8] at the grain-ice interface. 2. If similar processes are present for the smaller spots at steep slopes, they may be part of slope streaks activity by ice melting. 3. The water ice concentration/separation mechanism may have other astrobiological importance [11] and implications for climatic parameters [12].

5. Acknowledgements

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6. References

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