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CO_2 ice state at the Martian dark spots

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Abstract

Dark spots are seasonal geomorphologic patterns present at high latitude on Mars with a controversial origin implying liquid water or CO_2 gas or other fluids. In order to better constrain their formation, we investigated the physical state of CO_2 ice using CRISM/MRO hyperspectral images, and the morphology using HiRISE/MRO data.

1. Introduction

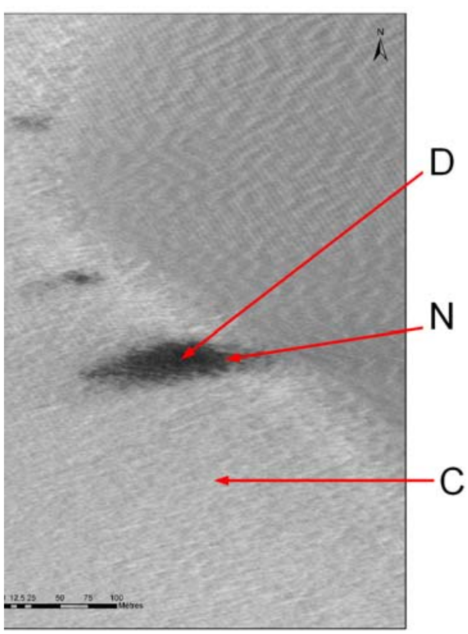

Figure 1 : Example of one of the dark spots studied. D is the dark spot centre, N is a neighbour within the feature, and C is a control point out of the feature. Image HiRISE PSP_002885_1080, Ls = 197°, -72°N, 179.4°E.

One class of model proposes that dark spots are formed in presence of liquid water below the CO_2 ice [2]. Alternatively, the Kieffer model assumes a CO_2 jet formed by sublimation beneath a translucent slab ice, carrying dust from the regolith [3]. Depending on wind direction and intensity, the dust particles create the dark spots around the ejection point [5]. We investigate here the dark spot features at the top of the dune because they appear to be late enough to be observed from the beginning of the evolution.

2. Method

We focused on Richardson crater dune field, as it was the best time covered place we could find for CRISM data. The ten images dataset ranges from a solar longitude of 175° to 248°. On the last image, the CO_2 ice layer has almost disappeared. We selected some dark spots at the top of a dune. For each spot, we selected the spectrum of the ejection centre, a spectrum from the very near neighbourhood, within the feature, and a control spectrum, in the near neighbourhood, out of the feature. We took care to follow the evolution of the same three locations for each dark spot.

We computed from each spectrum the reflectance of the continuum at 1.13 µm , the CO_2 ice band depth at 1.435 µm and 2.3 µm [4], the water ice band depth at 1.5µm [4], and an slab index. The slab index estimates the CO2 slab depth using the GRSIR method [1], which is a very fast inversion method. This index was previously built for OMEGA data but we adapted it to CRISM data. This index is based on the photon free mean path in the case of translucent slab ice. It is build to be close to zero when the ice is granular (grain size < 1 cm).

3. Results

Figure 2 shows the slab ice index evolution for one dark spot. At Ls = 175°, the three index are similar and high, indicating that the ice is homogeneous and translucent in the dune. HiRISE data confirms that the dark spot has not already appeared. At Ls = 181°, the dark spot centre index (so called "D" for the rest of this abstract) and its neighbour one ("N") have nearly the same value which is significantly lower than the control point one ("C").

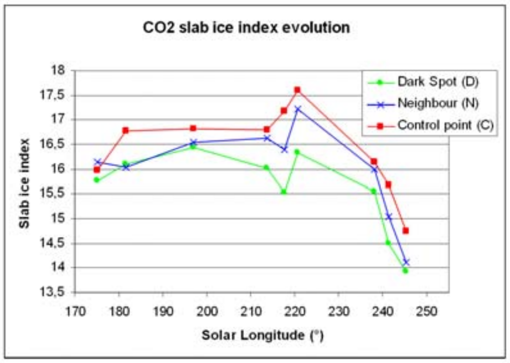

Figure 2 : Example of slab ice index evolution for one selected dark spot and its neighbour, with a control point.

The dark spot has appeared in the meantime. At Ls=197°, D and N have come closer to C in the same way. That could mean that some of the dust was eliminated in the meantime, without other ejection. The joint HiRISE image don't show significant differences between this image and the previous one. At Ls=213°, N has kept coming closer to C, but D decreased, suggesting a new ejection. HiRISE data show that a dark flow appeared. The evolution suggest then a new ejection between Ls= 213° and 217° followed by dust elimination (not clearly confirmed by HiRISE data) and after Ls=220°, a general CO_2 ice sublimation.

4. Discussion

The atmospheric component, especially the aerosols may contribute to the previous estimation of ice state at the ground. We checked that the optical depth data [6] show an anti-correlation with our CO_2 ice band depth until Ls = 238°. Then the correlation is lost, probably due to sublimation at the surface. However, the slab index seems robust and shows no correlation with dust optical depth. This allows us to say that general sublimation had already begun before Ls=238°. All parameters show a significant peak for the four dark spots studied, including the control point. This is consistent with an external parameter that biases the slab index. That coincides with an important peak of water ice aerosol measured by M. Wolff on that image.

All the dark spots studied show evidences of at least two major ejection events, visible on both CRISM and HiRISE data : a morphologic event is linked to an ice state evolution.

5. Conclusion

Our spectroscopic studies indicate that the CO2 ice is translucent before the dark spot formation and that the ice is becoming more and more translucent around the spot. We showed that each dark spot event seems to be linked to a local decrease in the translucent state within the dark spot suggesting that the flow is actually covering the ice, blanketing it rather than below. These observations are more in favor of Kieffer model. In the future, more accurate quantitative physical parameters can be estimated thanks to radiative transfer model inversion.

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