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Laboratory hyperspectral studies of ice/regolith associations. Application to icy surfaces on Mars.

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1. Context

Ices are ubiquitously present on Mars. Whether it is in the form of H_2O or CO_2, they are found at almost all latitudes over the atmosphere and surface of the red planet. Depending on the surface and atmospheric conditions −temperature, pressure and humidity, ice will appear under various forms and will therefore interact in different ways with the substrate, i.e the regolith. From stable and seasonal polar caps to low latitude diurnal-cycled frosts [1, 2] through high-latitude covered permafrost [3]. When it comes to its detection and quantification, this variety is also a challenge. Spectral or colour imaging and reflectance spectrometry stand out as the techniques needed to *i)* detect the ice on the surface, *ii)* characterize its association mode with the regolith (grains, frost, slab…) and *iii)* determine the ice concentration. Both global and local coverages are important; on one hand, near-global coverage such as the one provided by the OMEGA spectrometer [4] and the stereo camera HRSC [5] are key to understand the big picture and to identify scientific targets. On the other hand, the higher resolution provided by the spectrometer CRISM [6] and colour cameras HiRISE and CaSSIS [7, 8], is crucial to study local phenomena. Currently inserted into Mars orbit and about to start the aerobraking phase, the ESA's Trace Gas Orbiter (TGO) transports the Colour and Stereo Surface Imaging System (CaSSIS), with four colour bands (475nm (BLUE), 650nm (PAN), 850 nm (NIR) and 950nm (IR)). CaSSIS will complement the data of other cameras thanks to the non-Sun-synchronous orbit of TGO around Mars and the high signal-to-noise ratio of the instrument, which will allow us to observe in good conditions not only seasonal phenomena but also diurnal ones, such as H_2O and CO_2 frosts.

Laboratory measurements are essential for the interpretation of these data. We study whether visible and near-infrared spectro-photometric signatures can help us identifying water frost from orbit or for example, distinguishing between water adsorption by the regolith and frost deposition on it. Through hyperspectral imaging we analyze the spectra and colour of well-known and characterized samples, which allows us to recognize signatures associated to different ice-soil association modes, for instance intimate or areal mixtures. We have carried out a campaign of measurements covering a wide range of parameters of interest (ice/soil ratio, association mode, H_2O/CO_2 ice) and analyzed their spectra to identify key features. At the same time, we simulate the colours of our samples as would be seen by CaSSIS, characterizing their different signatures depending on their nature. This enables us, among others, to assess the filter combinations that will be more efficient to use for different CaSSIS targets, that is, which filters should be used when it comes to detect and characterize ice, minerals, etc.

2. Samples and experiments

The measurements have been carried out in the LOSSy at the University of Bern, using our simulation chamber SCITEAS [9] and according to the various ice production methods that we have developed through time [9, 10]. We have produced samples with particulate water ice of different grain sizes, mixed with different ratios Mars soil analogues and ices, deposited water frost over Mars analogue surfaces (JSC Mars-1, [11]) as well as studied CO_2 ice signatures. Hyperspectral imagery implies that for every pixel imaged, a full spectrum between 0.38 and 2.4 μm is available. For each experiment, a color analysis is also carried out (Fig 2).

We will present the results of our campaign. Average spectra will be shown, such as the example in Fig 1, where we can see the spectra of CO_2 ice for different particle sizes and how our samples are contaminated with water frost depending on their size. Also colour simulations such as Fig 2, where CaSSIS filters are combined to obtain the best combination to discern water ice from JSC Mars-1. A series of spectral and colour analyses will be presented along with the consequences for ice detection from orbit.

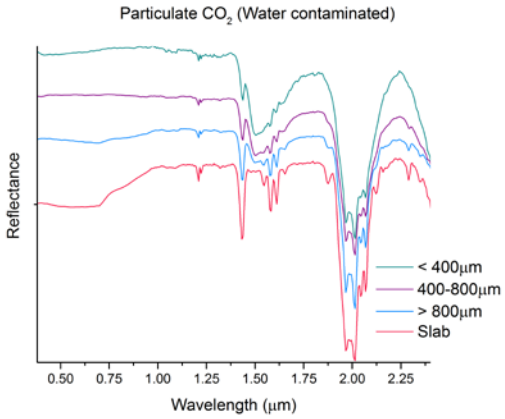

Figure 1. Slab and particulate CO_2 ice contaminated by H_2O. Smaller CO_2 particles have cold-trapped water from the atmosphere. The slopes between 0.7 and 1.0 μm on the >800μm and slab spectra are measurement artefacts.

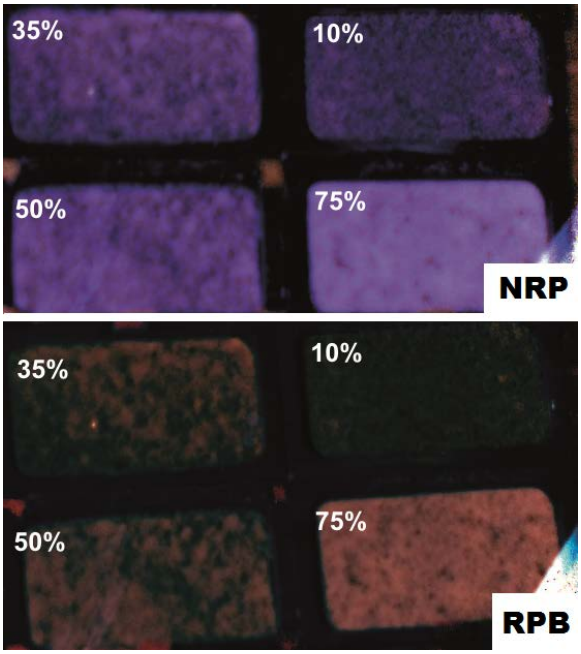

Figure 2. Different weight % of ice (marked next to each sample). RGB composites of CaSSIS Near-Red-Pan filters (on top) and Red-Pan-Blue (on bottom).

Acknowledgements

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References

[1] Piqueux, S., et al, 2016. Discovery of a widespread low-latitude diurnal CO2 frost cycle on Mars, J. Geophys. Res. Planets, 121, 1174–1189, doi:10.1002/ 2016JE005034.

[2] Smith, P. H. et al., 2009. H2O at the Phoenix Landing Site. Science Vol 325

[3] Mangold, N., P. et al 2002, Experimental and theoretical deformation of ice– rock mixtures: Implications on rheology and ice content of Martian permafrost, Planet. Space Sci., 50, 385– 401, doi:10.1016/S0032-0633(02)00005-3.

[4] Bibring, J.-P., et al. 2004, OMEGA: Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité, in Mars Express: the Scientific Payload, edited by A. Wilson and A. Chicarro, ESA Spec. Publ., ESA SP‐1240, 37–49.

[5] Jaumann. R., et al. (2006) The high-resolution sterei camera (HRSC) experiment on Mars Express: Instrument aspects and experiment conduct from interplanetary cruise through the nominal mission. Planetary and Space Science. https://doi.org/10.1016/j.pss.2006.12.003.

[6] Murchie. S, et al. 2007. Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) on Mars Reconnaissance Orbiter (MRO). Journal of Geophysical Research. doi:10.1029/2006JE002682.

[7] McEwen S. A., et al. 2007. Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment (HiRISE). Journal of Geophysical Research. doi:10.1029/2005JE002605.

[8] Thomas, N. et al, 2016. The colour and stereo surface imaging system for ESA's trace gas orbiter. LPSC 47.

[9] Pommerol., A. et al., 2015a. The SCITEAS experiment: Optical characterizations of sublimating icy planetary analogues. Planetary and Space Science, http://dx.doi.org/10.1016/j.pss.2015.02.004i

[10] Poch, O. et al., 2016. Sublimation of ice–tholins mixtures: A morphological and spectrophotometric study.Icarus, http://dx.doi.org/10.1016/j.icarus.2015.11.006

[11] Allen C.C., et al., 1998. JSC MARS-1: A Martian Soil Simulant. Space, 469–476. DOI:10.1061/9780784403396