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Experimental, spectral and colour analysis of H_2O and CO_2 ices and dust samples. Application to Martian icy surfaces.

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1. Introduction

At the Laboratory for Outflow Studies of Sublimating icy materials (LOSSy, Bern) [1], we have studied the VIS-NIR reflectance of a variety of H_2O/CO_2 ices and Martian regolith analogues associations. Last year, we presented our preliminary results at EPSC [2]; this time, we propose to present the complete results of both H_2O and CO_2 samples, and how to use them to fully exploit data acquired from the surface of Mars.

We will also present the first applications of our work by analysing some images acquired with CaSSIS, the colour camera on board TGO [3]. CaSSIS, whose characteristics make it ideal to monitor volatiles such H_2O and CO_2, has already started sending images from the Martian surface [4,5].

2. Samples and methods

2.1 End-members

We have used, as Martian simulants, the Martian soil analogue JSCM-1 [6] and a more pristine dark basalt [7]. As ice simulants, we have used the grained, water SPIPA ices [8] and CO_2 ices in the range of the hundred micrometres.

2.2 Associations

- *Intimate mixtures*: salt-and-pepper like mixtures of dust-H_2O ice, dust-CO *Intimate mixtures*: salt-and-pepper like mixtures of dust-H_2O ice, dust-CO_2 ice and CO_2-H_2O ices.
- *Frost on dust*: condensed atmospheric water onto both JSCM-1 and dark basalt.
- *Frost on intimate mixtures*: condensed atmospheric water onto dark basalt and water ice intimate mixtures (serendipitous samples)
- *Frost on CO_2 slab*: water frost condensed onto a slab of CO_2.
- *Frozen soils*: matrix of water ice surrounding JSCM-1.

2.3 Spectral and colour analysis

We have measured the reflectance spectra (0.4-2.4 μm) of the samples within our simulation chamber, SCITEAS [1]. Second, we have conducted an analysis of the absorption bands and spectral slopes of the spectra. Finally, we have used the ground-calibration data from CaSSIS [9] to convolve our reflectance measurements with the spectral response of CaSSIS.

3. Results

Frost deposition: we observe three stages of spectral changes. In the first one, the substrate is almost homogeneously covered by fine particles; photons have a large probability of encountering ice. The great surface-to-volume ratio of tiny particles makes the reflectance increase. As frost grows thicker, the probabilities for photons to encounter ice barely increase, whereas the path length inside ice gets longer. Hence, we observe a deepening of the absorption bands rather than an increase of reflectance. In a third step, the highly-scattering frost layer masks the substrate beneath.

Intimate mixtures: the probability for a photon to encounter ice at the surface is smaller than in the case of frost. Once the photon finds a grain of ice, its chances of being scattered increase for greater surface-to-volume ratio of the ice grain. In this way, bigger particles are more likely to absorb or transmit the photon deeper into the soil. The reflectance of intimate mixtures with coarse ice grains is generally lower than the one of mixtures with fine ice grains.

At wavelengths that correspond to water absorptions, the situation can twist since coarse enough ices become the absorptive material of the mixture. At these locations, the great absorptivity of water becomes predominant in the reflectance spectrum.

Frozen soils: here, water is almost a continuum medium, which results in a low surface-to-volume ratio; samples are highly absorptive and the bands saturate. When cracks appear inside the slabs, the surface-to-volume ratio increases, raising the reflectance. The BLU colour of water, nevertheless, is still distinguishable.

CO_2: When dust is mixed with CO_2 instead of H_2O ice, reflectance behaves in a similar way since CO_2 is the non-absorptive component of the mixture and dust the absorptive one. In mixtures of CO_2 and H_2O ices, water ice becomes the absorptive component. Thus, water ice behaves in an H_2O-CO_2 mixture as JSCM-1 behaves in an H_2O-JSCM-1 one; its spectrum predominates the reflectance spectrum of the mixture. H_2O and CO_2 are almost indistinguishable from their colour in the visible.

4. Application to Mars

Figure 1 shows the comparison of the PAN/RED and BLU/RED ratios with the RED band of the laboratory samples. For simplicity, we have grouped the samples by their association mode and presented the trends they draw as the presence of ice increases (direction of the arrows).

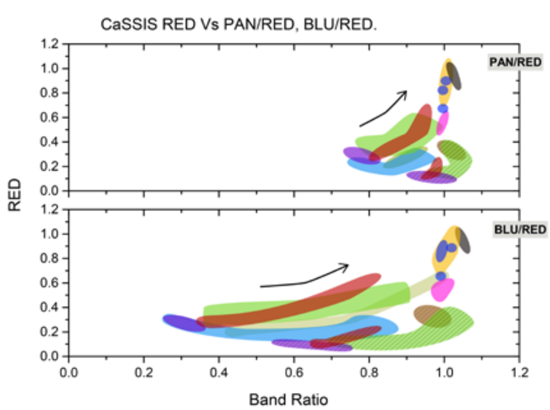

Figure 1 CaSSIS RED band vs PAN/RED and BLU/RED band ratios.

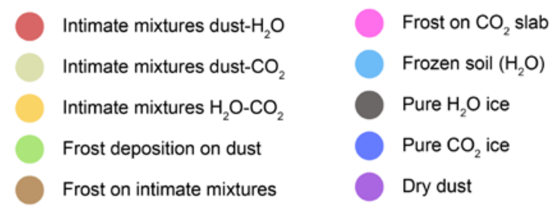

Figure 2 Colour legend for Fig. 1

Depending on their association mode and their ice percentage, samples mark different trends (notably in the BLU/RED plot). The filters of CaSSIS and those of HiRISE are comparable [3]; we will therefore compare the colours of the laboratory samples with the ones of Martian surfaces acquire with HiRISE.

At this conference, we will be able to show the first analysis of CaSSIS images. Of special interest for us will be the study of the colour evolution of the surface in a daytime scale and the changing colours of the retreating, southern, seasonal polar cap.

Acknowledgements

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