SPRING SUBLIMATION ON MARS: DO NORTHERN AND SOUTHERN HEMISPHERES TELL US THE SAME STORY?

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Introduction: We present an overview of HiRISE observations of spring evolution of selected dune areas of the north polar erg and compare them to spring observations in the southern polar areas.

The north polar erg is covered annually by a seasonal volatile ice layer, a mixture of CO_2 and H_2O with mineral dust contamination. In spring, this layer sublimes creating visually enigmatic phenomena, e.g. dark and bright fan-shaped deposits, dark–bright–dark bandings, dark down-slope streaks, and seasonal polygonal cracks. Similar phenomena in southern polar areas are believed to be related to the specific process of solid-state greenhouse effect (so called Kieffer's model) [1]. In the north, it is currently unclear if the solid-state greenhouse effect is able to explain all the observed phenomena especially because the increased influence of H_2O on the time scales of this process has not yet been quantified.

North vs. South: The conditions during northern winter and spring are very different from those during southern. The northern hemisphere is known to be more humid than the southern [2]. Hence more inclusions of water ice are expected in the seasonal CO_2 layer. Most of volatile deposition happens during dark winter season which makes it extremely hard to observe with passive remote sensing instruments. Inclusions of water might change both optical and mechanical properties of CO_2 slab. Water crystals act as light scatterers inside the slab making it less transparent. They also compromise the integrity of CO_2 crystal structure in hardly predictable ways. Topographically north polar areas are lower than southern by up to 7 km which leads to pressure differences during local spring of up to 400 Pa. This is a very different thermodynamical environment for CO_2 and H_2O phase transitions.

Spring similarities: Despite all the mentioned differences, during seasonal sublimation of volatile layers we observe phenomena common for both hemispheres:

- in the very early spring observations all surfaces have a reflectivity lower than 0.4 – this number is below the reflectivity expected for a granular CO_2 or H_2O ice-covered clean surface.
- all the monitored areas follow similar trends in reflectivity: a phase of brightening with a maximum appr. 110 sols after equinox and subsequent darkening with complete CO_2 sublimation in 50 more sols. Fig. 1 shows an example of the brightening phase in 3 consequent years in Buzzel area. This brightening is observed in both hemispheres, while the composition of the top surface layer as inferred by NIR spectroscopy shows differences: in southern hemisphere brightening correlates with increase of CO_2 signature, while in the northern – with H_2O signature [3, 4];
- dark and bright fans, blotches, cracks in the ice layer are observed in both hemispheres [5, 6];
- in spring fans appear first in the areas with the irregular small-scale topography, like araneiforms in the south and patterned ground between dunes in the north. Later the activity spreads to more even and smooth surfaces, like dunes.

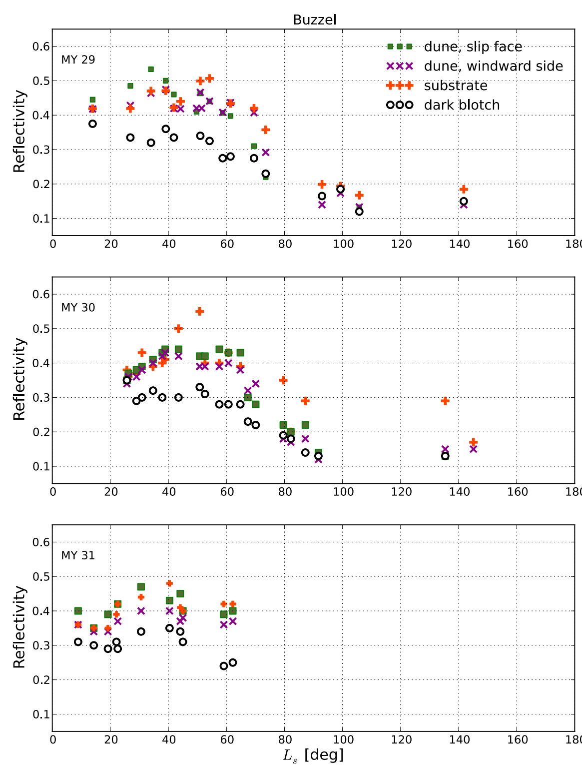

Figure 1 Temporal evolution of HiRISE red band reflectivity of four surface types in Buzzel area (83.7°N, 235.7°E) during three consequent martian springs.

Spiders in the south – furrows in the north: In the northern polar areas all above mentioned active processes happen on the polar erg – vast field of dark dunes. In the southern hemisphere no such vast dune field exist. There are intra-crater dunes in high latitudes in southern hemisphere which show sublimation features remarkably similar to the polar erg in the North (Fig. 2) and also show more surficial water ice than other southern polar terrains. The timing of sublimation events however is shifted here. This most probably can be explained by difference in absolute latitude of southern inter-crater dunes and northern polar erg.

Intra-crater dunes are rather exceptional among active areas of the south. The most common terrain where a lot of spring activity happens is araneiform terrains. Araneiforms are only found in the south. In the north, where all the spring activity happens over the dunes, signs of it get easily erased during summer. Indeed furrows – tiny channels associated with fans – were observed in the north [7]. They appear every year in spring with slightly different positions and shapes. Summer migration of dune ripples does not let furrows develop into something similar to araneiforms of the south.

Conclusions: All the similarities in spring activity that we observe in polar areas point to the fact that same processes (related to the solid state green house effect) act in both hemispheres. In the north, water ice has a stronger influence on the evolution. We need further investigations to clarify how water ice contamination modifies Kieffer's model. We believe that it might be, for example, responsible for prominent blue halos and dark-bright-dark bandings observed here.

References:

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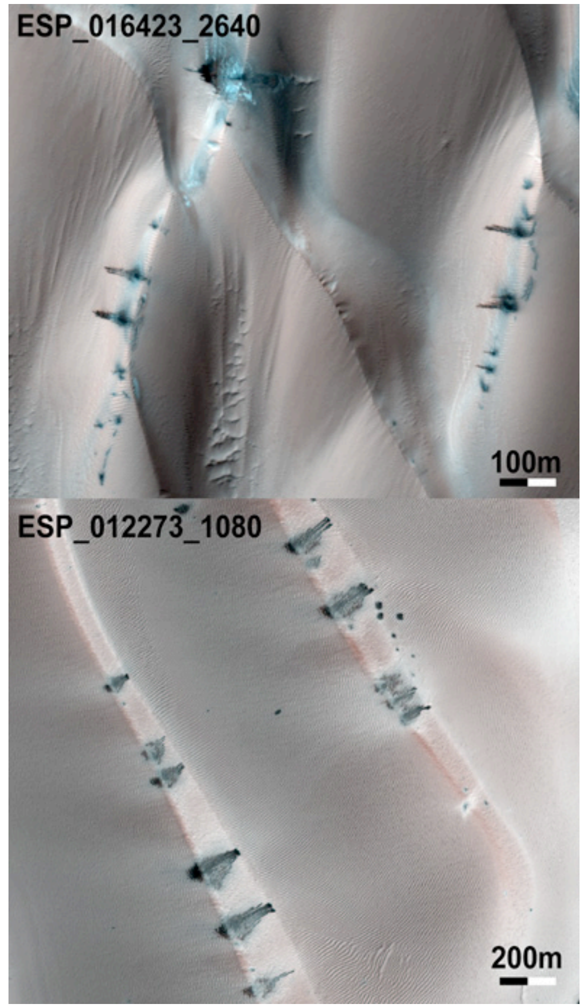

Figure 2 Sublimation features in the northern polar erg (Buzzel: 83.8°N, 235.3°E) – top panel; and over dunes inside Richardson crater in south (72°S, 179.4°E) – bottom panel.