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Supporting Online Material for

Seasonal Erosion and Restoration of Mars' Northern Polar Dunes

C. J. Hansen,* M. Bourke, N. T. Bridges, S. Byrne, C. Colon, S. Diniega, C. Dundas, K. Herkenhoff, A. McEwen, M. Mellon, G. Portyankina, N. Thomas

*To whom correspondence should be addressed. E-mail: cjhansen@psi.edu

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Supplementary On-line Material

1. The "Kieffer" Model

In the south polar regions of Mars exotic phenomena associated with spring sublimation of the seasonal CO_2 polar cap were first modeled by Hugh Kieffer (1). He proposed that an area called the cryptic terrain (because of its low albedo and low temperature in the spring) was covered with translucent ice that allowed sunlight to penetrate through and warm the surface below the ice. This source of energy, in addition to subsurface heat conduction, causes the layer of seasonal ice to sublimate from the bottom (2). In this scenario the gas is trapped under the ice until a weak spot ruptures, opening a vent for the pressurized gas to escape. Escaping gas entrains surface material, flows out ruptures in the surface ice, and carries the surface fines to the top of the ice layer. The fines are deposited downwind of the vent in fan-shaped forms in a direction determined by the ambient wind. Various aspects of the Kieffer model have been developed and expanded over the years to explain a variety of springtime south polar features (3-9).

Basal sublimation of CO_2 ice is the key element of the Kieffer model. We have been exploring differences between the hemispheres, and the images that led to the findings in this paper were taken in order to investigate northern springtime phenomena. It is not safe to assume that the northern and southern hemispheres will be the same – Mars' elliptical orbit means that the southern winters are longer,

more CO_2 condenses, and it takes longer to sublimate. In the images we see similarities and differences: basal sublimation entraining sand from the dunes is a likely explanation for the fans that we see on northern dunes. Cracks in overlying surface ice can explain dark polygons that disappear when the CO_2 is gone. We have no explanation for the bright-dark-bright banding observed in many places, including the stoss side of the dunes, shown in Figure 2 and 5, that has no southern hemisphere analog. The dunes are quite dark (we estimate a reflectance of ~0.15 in one of the dune fields imaged), and we estimate that just a fraction (~10%) of sunlight would be required to penetrate the CO_2 layer to warm up the sand enough to cause basal sublimation.

Most recently our group has been using a commercial fluid dynamics code (called Phoenics) to quantify characteristics of the plumes of escaping gas such as outflow mass, velocity, and vent geometry that produce the fans seen in HiRISE images. Although the primary emphasis of the gas flow investigation is south polar phenomena, we have also looked at predictions for conditions in the northern hemisphere. The detailed findings from this investigation will be reported in a future paper which has just been submitted to Geophysical Research Letters – the most important result for this paper is that gas flow speeds of >10 m/sec under the ice and exiting the vent are predicted. This is sufficient to move grains of sand and thus trigger avalanches on the slipfaces of the dunes.

2. Quantity of sand moved

Some grainflows move hundreds of cubic meters of material. Figure S1 shows one such example.

References

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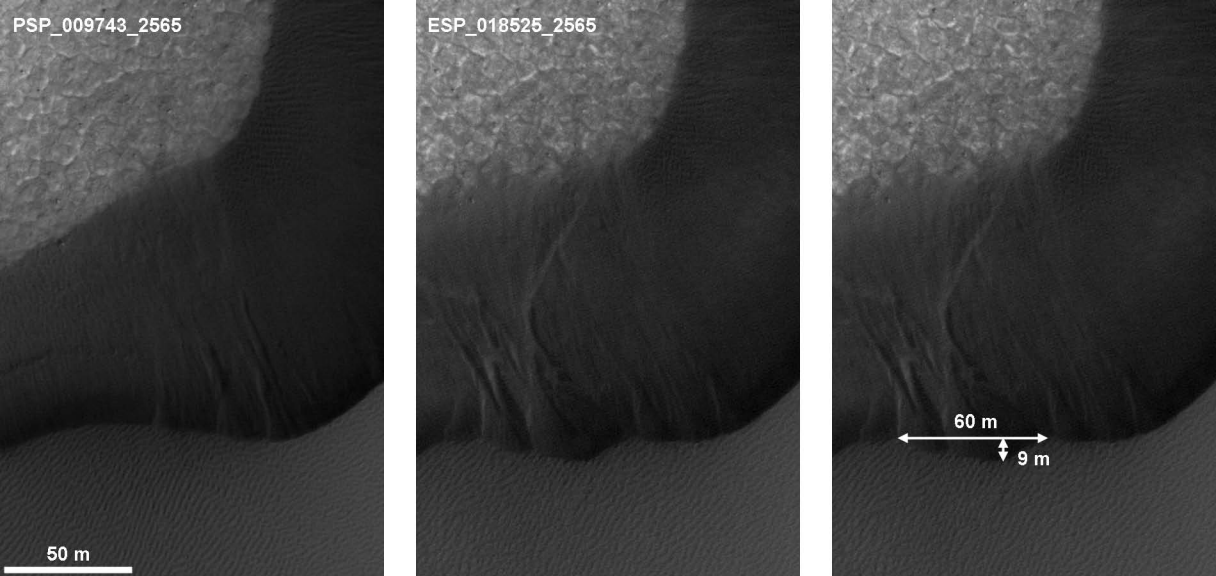
SOM Figure Caption

SOM Figure S1:

Mars Year (MY) 29 and MY30 comparison shows a large new alcove, gullies and broad apron. The dimensions indicated are consistent with downslope movement of hundreds of cubic meters of material.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50 m
60 m
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