SEASONAL CHANGE IN NORTH POLAR DUNE MORPHOLOGY SUGGESTS THE IMPORTANCE OF CRYO-AEOLIAN ACTIVITY. Mary C. Bourke, Planetary Science Institute, Tucson, Arizona, 85719, USA. mbourke@psi.edu

Introduction: The temporal resolution of HiRISE images now permit the detection of changes in dune morphology in sequential Mars Years. Several important discoveries have been made that are relevant to North Polars dune and ripples. First, polar dunes are actively migrating [1]. Second, dune lee slopes have fresh grain flow deposits, triggered during CO_2 sublimation, and third newly-formed alcoves are reworked by ripples [2]. Fourth, each spring, shallow curvilinear features are newly formed on dune surfaces during seasonal CO_2 sublimation. These furrows are reworked by ripple migration on the dunes during spring and summer [3]. Here further change to North Polar dunes is described. The aim is to identifying the nature of the change, and assess the role of cryo-aeolian processes.

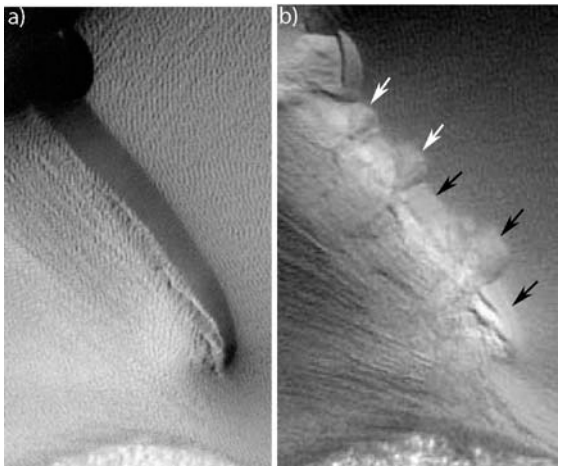

Figure 1: Seasonal slumping on dune avalanche face. a) Subset of HiRISE image taken 7th September 2008. b) Subset of same location taken on 13th August 2010. Black arrows indicate slumps and white arrows indicate later grainflows.

Mass wasting on the lee slopes of transverse dunes is an important component of sediment transport and it takes several forms (e.g., dry grain flows, translational and rotational slumping). The style of failure is dependent on slope characteristics and sediment cohesion. In cold deserts on Earth, cohesion is provided by moisture, pore ice and frozen layers of snow and ice. Cementation can result in oversteepened slopes which fail and slump onto the dune lee slope once temperatures increase. Upper lee slopes develop tensionsl fissures which may detach and form slab slides. Subsurface loss of volume due to melting on lee slopes cause the development of compressional folds that appear as mid-slope ridges [4].

Data is presented here that suggest there is a morphological response on Martian dunes to increasing seasonal temperatures.

Dune change and recovery:

Rotational Slump. Morphological change was observed on dunes throughout the North Polar sand seas. While many dunes show the formation of fresh alcoves and their deposits, others display more significant morphological change. Figure 1 is an example of change to a dune over one Mars Year. The morphology of the dune in Figure 1b indicates that the entire length of the dune brink was subject to individual, large (~30 m wide) slumps, two of which have a runout distance of ~20 m from the base of the lee slope.

Failure morphology indicates a rotational shear plane suggesting sediment cohesion and failure at significant depth. The slumps are overprinted by dry grainflows. Sediment movement on the slipface in this example is a two stage process: a) the failure of ice-cemented sediments followed by b) a phase dry grainflows. The dry grainflows modify the slump morphologies and potentially bury the ice-rich slump deposits.

Sinkholes:

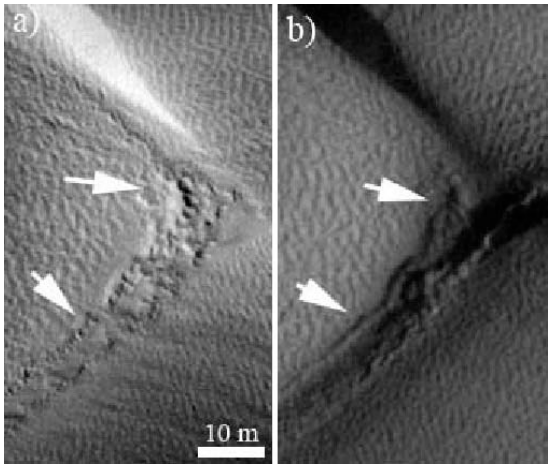

Figure 2: Sinkhole recovery on dune in Chasma Boreale. a) Subset of HiRISE image taken 11th November 2006. b) Subset of HiRISE image at same location, 20th September 2008.

Evidence that lee slope failure deposits may be ice-rich is supported by the formation of sinkholes in slumped deposits (Fig. 2a). Figure 2a shows the development of sinkholes in a 'string' formation at the foot of a lee slope. On Earth sinkholes form by a loss of volume in the subsurface, generally by melting of buried snow. In an image taken one Mars Year later, the

sinkholes show partial recovery (Figure 2b). The morphology of the former sinkhole location is now hummocky. On Earth sinkholes become hummocks as the sediments drape over remnant buried snow [5]. These HiRISE image data suggest survival of ice in the subsurface of slumped lee slope deposits on Mars. Subsequent burial of these deposits by slipface advancement during dune migration or by other slumping events will increase the preservation potential of ice in the dune.

Slipface ice lenses:

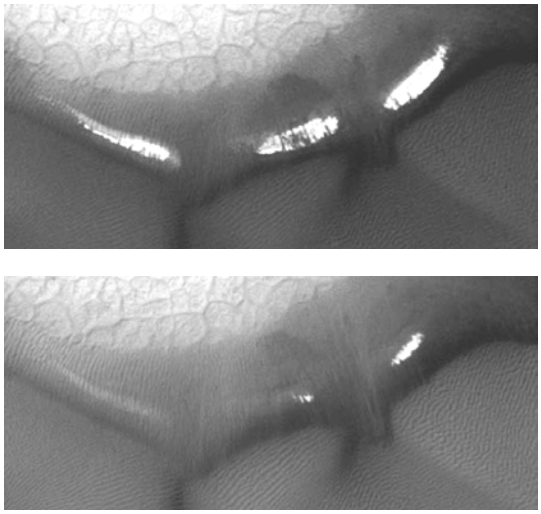

Figure 3: Sublimation and burial of ice on dune. **Top:** Residual ice patches buried and/or entrained by grainflows during northern summer (L_s=101.4°). **Bot:** Continued ice burial/entrainment by grainflows during later that summer (L_s= 117.3°).

The loss of seasonal ice from polar dunes by sublimation is spatially differential both at the dunefield scale and on individual dunes. This is primarily controlled by insolation receipts and perhaps a contribution by katabatic winds [6]. HiRISE data show that remnant icy patches remain on pole-facing, steep (and therefore shadowed) slopes well into summer (Fig. 3). Burial of residual ice deposits by lee-slope mass wasting is an important mechanism by which ice lenses are incorporated into dunes on Mars. Grainflows that are initiated at the mid and upper dune lee slope may entrain and/or bury ice along their path. In the example shown in Figure 3 grainflows continue to develop and bury the residual ice patches into the Martian summer. The relocation of the grainflow source alcoves along the dune brink ensure that large surface areas of residual ice are buried.

Conclusions:

- Significant morphological change occurs on the lee slopes of Mars' North Polar dunes.
- The morphology suggests mass wasting of ice-cemented dune brink sediments and the occurrence of dry grainflows.
- Ice-rich dune sediments and remnant lenses of seasonal ice are buried and preserved by grainflows and ripple deposits.
- Rapid burial of residual ice patches will preserve significant volumes of pure leinticular ice in dune avalanche-face strata. Slumped deposits at the slipface toe will be preserved as ice-cemented blocks and grains.
- The formation of cryo-aeolian deposits and their sublimation is an active process on Mars.
- As the rate of polar dune migration is on the order of > 2m/yr [1], recovery of masswasting scars should occur in 2-3 Mars Years. The recovery rate can be monitored in future observations.

References:

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