SLOPE AND VOLUME ANALYSIS OF ALCOVE-CHANNEL-APRON AVALANCHE MORPHOLOGIES WITHIN THE NORTH POLAR REGION OF MARS.

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Introduction: Various sand dune avalanche morphologies have been identified within the north polar region of Mars using images captured from the High Resolution Imaging Spectrometer Experiment (HiRISE) on the Mars Reconnaissance Orbiter [e.g., 1-4]. Typically, these morphologies consist of an alcove that transitions into a depositional apron, known as Alcove-Apron (AA) morphologies (Fig. 1). However, Alcove-Channel-Apron (ACA) morphologies (Fig. 2) have also been observed, with channels that are located between the alcove and apron. Channels were first identified within dune avalanche morphologies in a north polar dune field dubbed Palma located approximately 95.4°E 76°N in previous research that we have conducted. ACA morphologies had previously only been identified within southern mid-latitude dune fields [3].

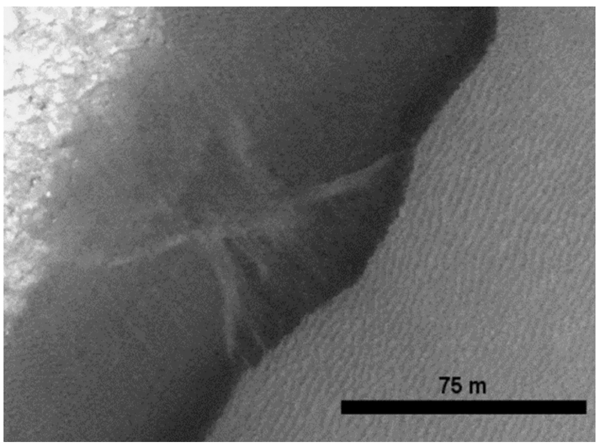

Figure 1: *Image of Alcove-Apron (AA) morphology on a sand dune. The brink of the sand dune is located near the center of the image and the upwind rippled slope extends to the right. The bottom of the dune is located on the top left. Image ID: ESP_018525_2565*

There is no clear evidence as to why channels form within some sand dune avalanches but not in others within the Palma dune field. One control that may influence channel formation is the slope at the location on the dune where the formation occurs. In this study, we calculated the alcove volume and the pre-flow and post-flow slope profiles of the AA and ACA morphologies to determine if slope and/or transported sand volume influences channel formation. Analysis of these potential controls can give us a better understanding of how sand particle interaction has a role in channel formation in sand avalanching.

Both aeolian and CO_2 frost processes are observed to modify the dunes in the northern region [2]. Current evidence suggests that the process creating both ACA and AA morphologies is related to the accumulation of CO_2 ice during the fall and winter periods and is also affected by sublimation of this ice during the spring period [2,5,6]. During the summer, wind transports sand throughout the dune field and around the dunes, refilling smaller alcoves over a period of 2-4 Mars years [2].

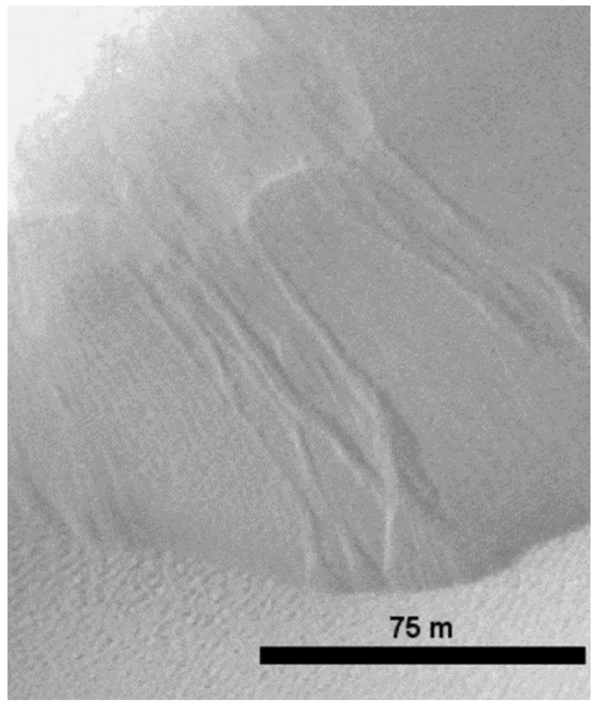

Figure 2: *An example of the Alcove-Channel-Apron (ACA) morphology. The dune brink, where the alcove begins, is near the bottom of the image and the bottom of the dune, including the aprons, is located in the upper left corner. Image ID: ESP_018525_2565*

Methodology: Sand dune avalanches in Palma were identified in Mars Years (MY) 29-33 in JMARS, a GIS software of Mars. For this study, avalanches identified as having formed in MY31 will be further analyzed by calculating the pre and post-flow slope profiles measured from digital terrain models (DTMs) at representative avalanche morphologies in MY30 and MY32, respectfully. Five representative morphologies for the ACA and AA classifications were then chosen for slope analysis.

Classification of the AA and ACA morphologies was solely based upon observable features of the formation. For example, the ACA must have a distinct channel with parallel walls between the alcove and apron (e.g., Figure 2). AA morphologies must have an alcove that transitions directly into an apron (e.g., Figure 1).

The slope, in degrees, was calculated by taking the gradient of the elevation at the dune brink to the elevation at the bottom of the dune and then by taking the arctangent of the gradient.

As the dune lengths for each formation vary, the slope profiles are plotted as a fractional portion of dune slope length as shown in Figure 3. To accurately compare the morphologies and their associated features, the feature lengths are normalized from 0% (e.g., representing the top of the alcove) to 100% (the end of the alcove, then repeated for the channel and apron).

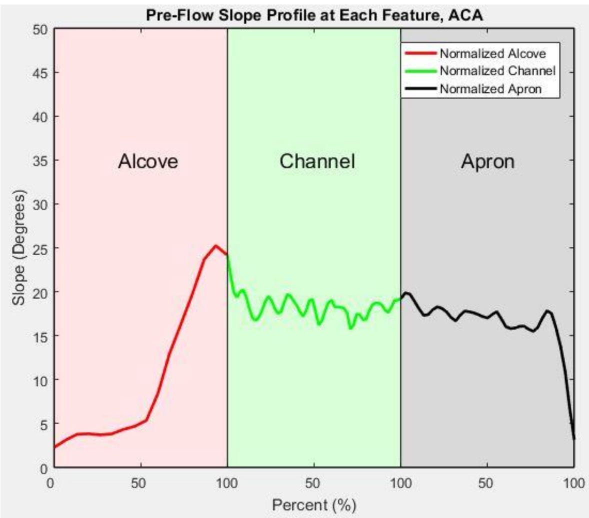

Figure 3: *Slope profile of a pre-flow ACA formation. Vertical lines represent transition locations at each feature.*

The amount of sand volume shifting downslope was also estimated for the AA and ACA morphologies. Alcove volume was measured for all AA and ACA morphologies for MY30 in JMARS. As the DTMs were not of a sufficient resolution for estimating the three-dimensional shape of the alcoves, we estimated the alcove volume by assuming the alcove depth as 1/100th of the alcove width. Also, we used the planform length as the alcove length (e.g. neglecting dune slope). The volume of the alcove was then estimated by using the equation $V = (l*w^2)/200$ where l is the alcove (planform) length and w is the alcove width. We then compared the alcove volume to the dune height where the avalanche formed, shown in Figure 4. The dune (planform) height was measured from the dune brink to the end of the dune.

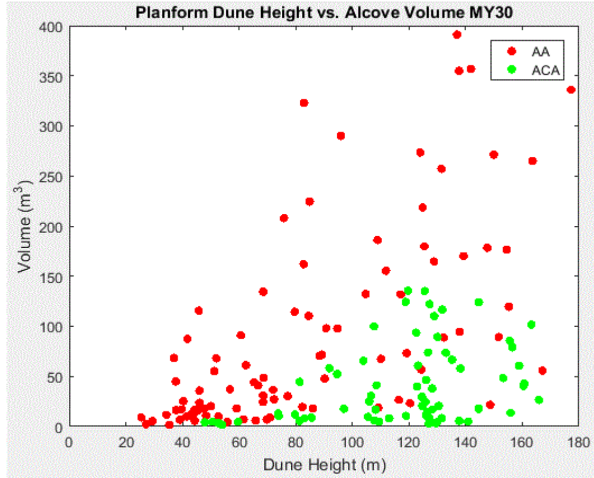

Figure 4: *Planform dune height vs. alcove volume, MY30. Green dots represent the ACA morphologies and red dots represent the AA formation.*

Results/Conclusion: Comparison of the pre-flow slope profiles for the AA and ACA morphologies where the alcove-channel transition occurs show no clear evidence that slope influences channel formation. The pre-flow slopes at this transition for the ACA and AA have similar slope ranges (15-28°). The similarities between the pre-flow slopes of the AA and ACA suggests the pre-flow slope value does not control channel formation.

In regards to the alcove volume and dune height, the ACAs tend to form when the planform dune heights are 50 meters or larger but also have smaller alcove volumes compared to the AAs at the same dune height. For example, large amounts of sand that is transported downslope on smaller dune heights will yield an AA. On larger dune heights, sand that is moved downslope have a longer slope distance within which channels are able to form, thus creating the ACA morphology. Further analysis of these morphologies and the mechanisms forming them will help us understand dune evolution as well as other CO_2 seasonal processes on Mars.

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