

POLAR DUNE MIGRATION AT SCANDIA CAVI, MARS: THE EFFECTS OF SEASONAL PROCESSES

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Scandia Cavi

Scandia Cavi dune field is dominately composed of linear dunes and is located (-150° E, 78° N), near the north pole (Figure 1). In this study, we have investigated the migration of linear dunes and the effects of CO₂ ice at Scandia Cavi over the time period 2008-2018. We have used HiRISE ortho images and a DTM available from the HiRISE node of the Planetary Data system (PDS) combined with change detection software, COSI-Corr⁽⁹⁾ to measure dune migration. HiRISE, CTX and HRSC have been used to observe and quantify the amount of CO₂ ice covering the dunes over time.

Dune Migration

The dune migration was measured using COSI-Corr, for the following time periods shown in Table 1 and Figure 2. The dunes were found to be migrating at approximately 2 myr⁻¹, with migration rates of 1.8, 2.0, 2.2, 1.3, 2.0 myr⁻¹ for ΔT1, ΔT2, ΔT3, ΔT4, ΔT5 respectively and sand fluxes of 35, 37, 42, 25, 39 m³m⁻¹yr⁻¹ respectively for ΔT1, ΔT2, ΔT3, ΔT4, ΔT5, showing similar migration rates and sand fluxes for each time period. Interestingly, the dunes are moving faster than other north polar dunes⁽²⁾ and the dunes also show a bimodal dune migration direction. During ΔT1, ΔT4 and ΔT5 the dunes are migrating east to east north east, whereas for ΔT2 and ΔT3 the dunes are migrating west, west south west. This showing there is a change in the dominant wind direction causing a reversal in the migration direction.

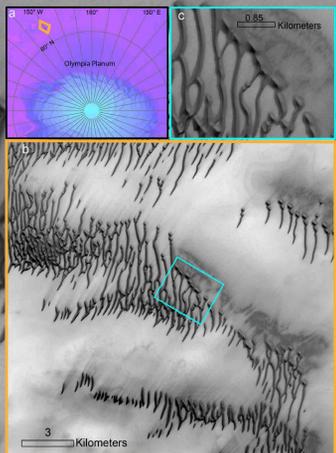


Figure 1: Location figure. a) shows Olympia Planum and the polar ice cap. Orange box shows the location of b. b) Scandia Cavi dune field. Blue box shows the location of c. c) shows the location of the dunes measured for dune migration and where ice patches were observed (Figure 6).

HiRISE Images	Time between images (days)	L _s first image	L _s Second image
ΔT1 PSP_009739_2580 ESP_027461_2580	1381	116.9	120.2
ΔT2 ESP_027369_2580 ESP_036217_2580	689.5	116.9	117.8
ΔT3 ESP_027461_2580 ESP_036217_2580	651	120.2	117.8
ΔT4 ESP_027461_2580 ESP_053755_2580	2048.5	120.2	114.8
ΔT5 ESP_036217_2580 ESP_053755_2580	1366	117.8	114.8

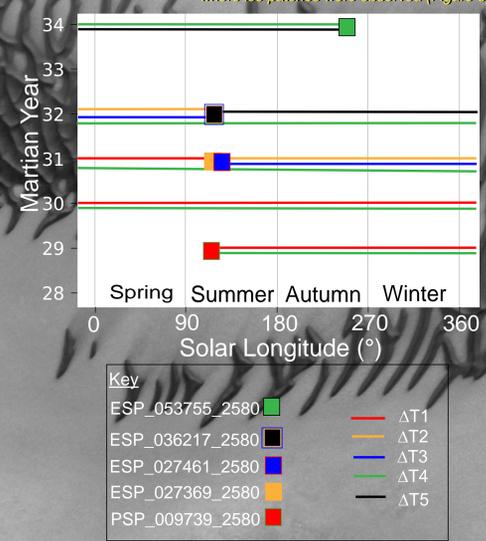


Figure 2: Chart showing the seasons for which each image was taken and the time periods and corresponding seasons for each set of image pairs.

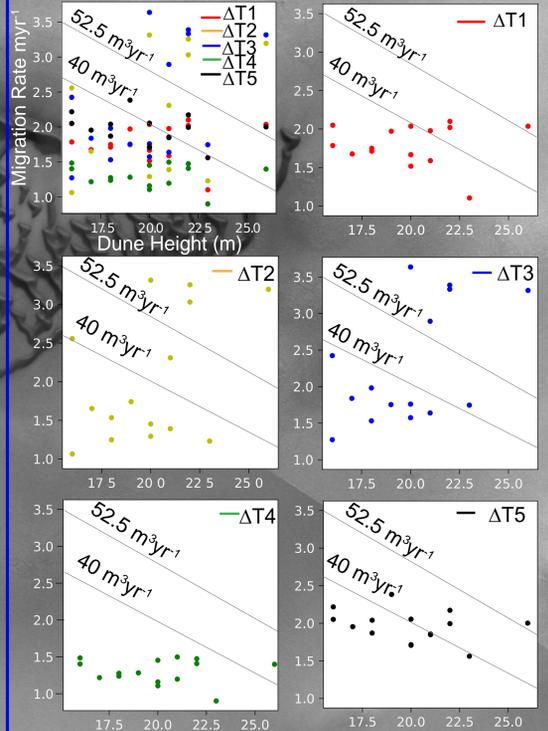


Figure 3: Plots of dune migration for each time period measured. Sand flux is shown by the diagonal grey lines.

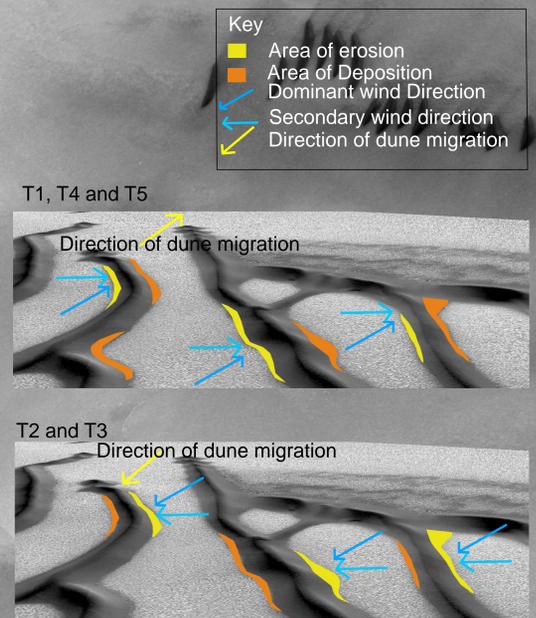


Figure 4: HiRISE DTM with no vertical exaggeration, showing the linear dunes. The annotations show the areas of deposition and areas of erosion for each time period along the slipfaces. We have observed a reversal in the direction of the dune migration and this can be seen in this image. During T1, 4 and 5 the dunes are migrating east to east north east. During T2 and T3 the dunes are migrating west to west south west, showing a change in the dominant wind direction.

CO₂ Ice Coverage

During the winter (L_s 270-360) the dunes become covered with ice and this is seen in the surrounding region as well (Figure 5). CO₂ ice freezes to the dunes, which is likely to limit the dunes movement to the spring and summer months when the ice has sublimated. The HRSC image of the dune field slightly further north of Scandia Cavi shows the dunes completely covered in ice during the winter with some sand being blown in to the area, causing some sublimation to occur. The CTX mosaic background shows the dunes at various times of year across several years. The range in ice cover is visible in this mosaic. From dunes covered with frost and ice, to dunes where sublimation has started to occur, where ice is only present around the rim of the dunes like the ones circled in blue. To dunes in the summer months being ice free, like the ones circled in red.

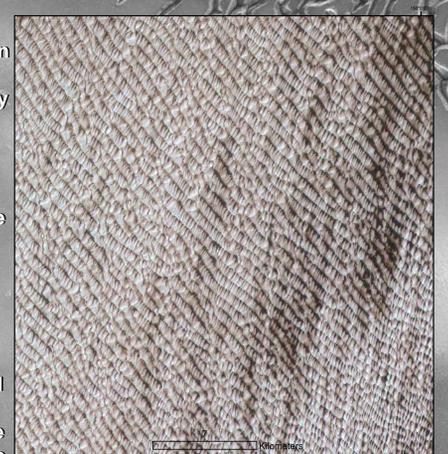
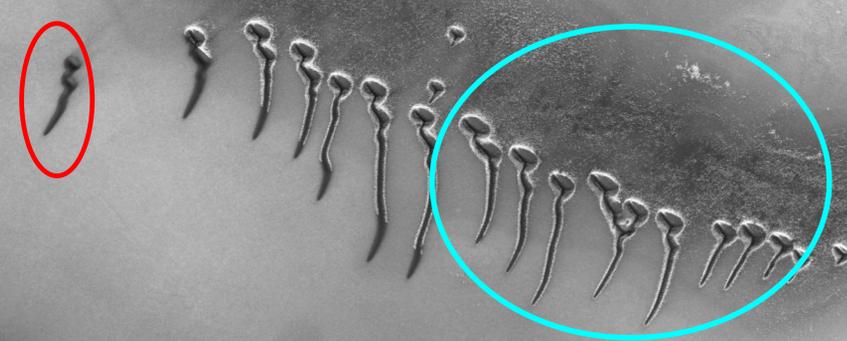


Figure 5: HRSC image 9796, showing the dunes in the surrounding region of Scandia Cavi, completely covered in CO₂ ice. Some dark albedo sand is seen covering some of the dunes, likely to have been blown into the area.



We found ice patches on some of the dunes in the HiRISE images that were taken in early summer. These ice patches are sheltered from solar insolation preventing sublimation from fully occurring until later in the summer. We have observed how the size of the ice patch in each image differs.

Image	Area of Ice Patch (m ²)
PSP_009739_2580	232
ESP_027369_2580	452
ESP_027461_2580	423
ESP_036217_2580	208
ESP_053755_2580	363

Table 2: Changes in the area of the ice patches, showing how rates of sublimation have changed each year.

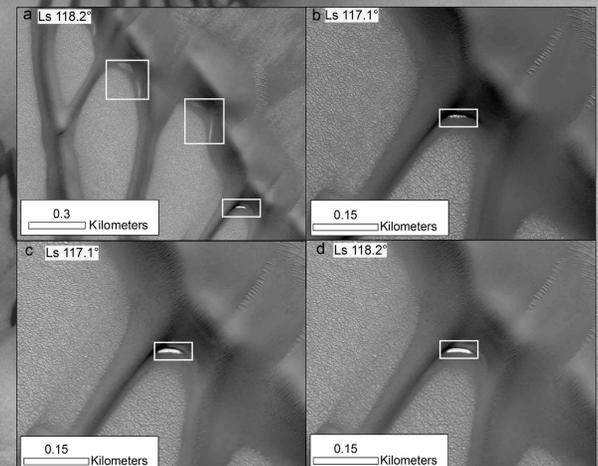


Figure 6: a-d show ice patches in each of the following HiRISE images taken during different years. White box outlines the area where frost/ice patches are visible. HiRISE images: (a) ESP_036217_2580, (b) PSP_009739_2580, (c) ESP_027369_2580, (d) ESP_036217_2580.

Acknowledgements
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 References: ¹Leprince, S. et al. (2007) IEEE J. Geosci. Rem. Sens., 45(6), 1529–1558. ²Chojnacki, M. et al. (2019), 47(5), 1–4.

