TRANSPORT CONDITIONS AND STAGES OF DUNE DEVELOPMENT IN THE OLYMPIA UNDAE DUNE FIELD.

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Introduction: The Olympia Undae Dune Field is the largest of the Martian circumpolar dune fields and displays a range of dune-field patterns. These patterns are here analyzed by crestline length, orientation and spacing. The patterns reflect spatial and temporal changes in the transport conditions under which the dune field evolved.

The purpose of this study is to analyze the dune-field patterns of one area of the Olympia Undae Dune Field in order to elucidate its transport conditions and stages of development. This area was chosen because of its location in the middle of the dune field and away from any significant topographic obstacles, which allows the regional wind regime to be assessed.

Dune-Field Description: At the field-scale, two sets of dunes are visible, which have nearly orthogonal crestlines, creating a reticulate pattern (Fig. 1A). The dominant crestlines (yellow, Fig. 1B) are oriented NNW-SSE (342°) and are more widely spaced and more continuous than the secondary crestlines (red, Fig. 1B), which are oriented ENE-WSW (060°).
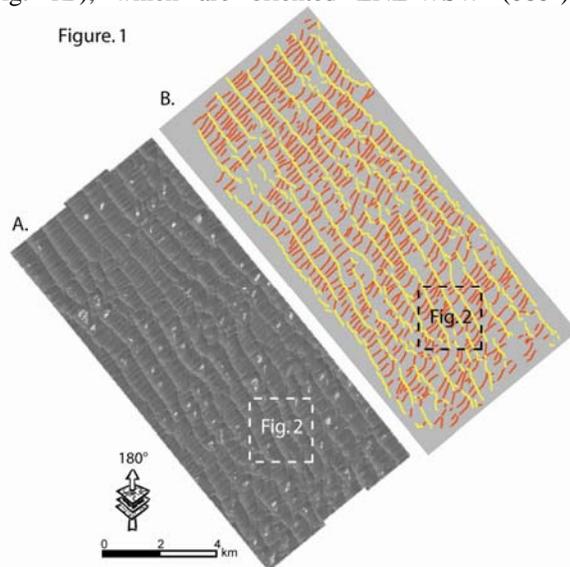

Figure 1. A. HiRISE image PSP_001432_2610 B. Digitized crestlines

Although the secondary crestlines are separated by the main dune crestlines, they often align end to end, which gives rise to the reticulate pattern. The SW terminations of the secondary crestlines are typically attached to the dominant crestlines, whereas many of the NE terminations are unattached (Fig. 2). At the point of intersection of the crestlines, scarp-like features are commonly present along the dominant crestline (green, Fig. 2). The scarps are oriented NNW-SSE (333°), which is perpendicular (93°) to the orientation of the secondary crestline and beveled 11° off the dominant crestlines (Fig. 3).

At the dune-scale, ripple are visible in the HiRISE image (Fig. 4). With the exception of small areas SW of the scarps and within the deflated interdune areas, the ripples are present over the dunes and change orientation in a systematic way related to their position on the dominant and secondary dunes.
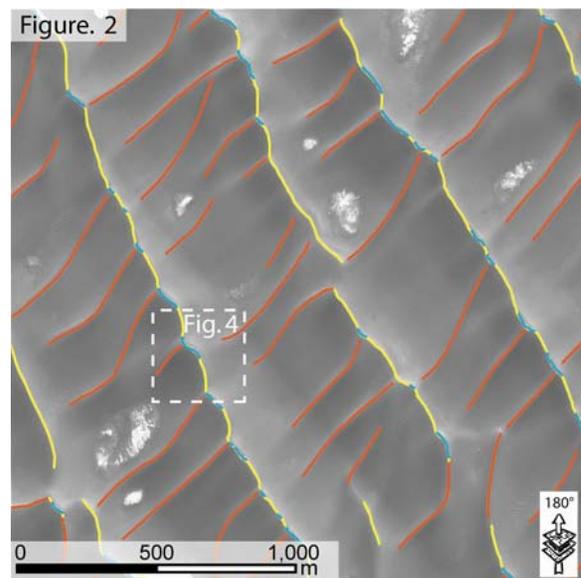

Figure 2. Inset from Figure 1 showing scarps (green) at the intersction of the secondary (red) and main crestlines (yellow).

Transport Conditions: Flow fields across the dunes and at the regional scale can be inferred by the relationships between the different scales of bedforms. The change in the orientation of the ripples over the dunes reflects the secondary flow over the dunes. Wind ripples, which are the smallest bedforms within a dune field, respond quickly to changes in the transporting winds, orient normal to the local flow direction and are detailed indicators of the most recent flow fields. The deflection of the ripples as they cross the main dune crestline indicates that flow is transverse to the orientation of the scarps, but oblique or longitudinal to the main crestline and longitudinal to the secondary crestline (Fig. 4). This suggests the dominant flow direction is from the ENE to the WSW, which matches estimates from other studies [1]. Ripples are absent

below the scarps, which would be in the lee shadow for a ENE wind, but reappear and recover to their orientation transverse to the ENE wind approximately 70m downwind of the scarp brink shadow zone and 80m west of the brink of the oblique portion of the main crestlines. On Earth, flow recovery occurs 3-5 dune heights from the brink [2] and on Mars is estimated near 5.6 dune heights [3], suggesting that this dune is ~12-23m high. The mean spacing of the main crestline is 632m (n = 61). The spacing to height ratio is 27-50, which is within the normal range of aeolian dunes on Earth.
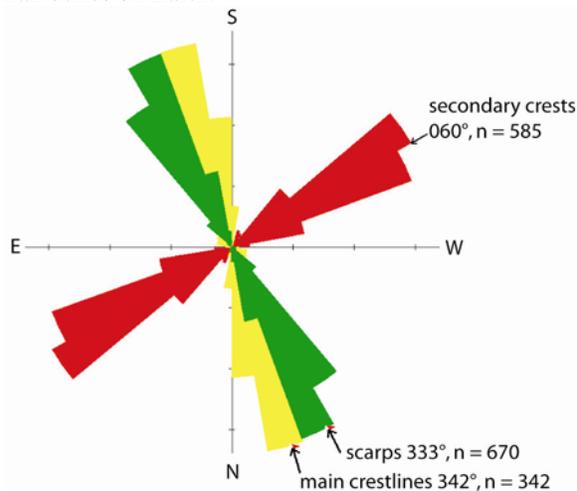

Figure 3. Rose diagram of main, secondary and scarp orientations.

The presence of erosional scarps at the crests of the main crestlines indicates that these dunes are stabilized and undergoing local scour. The position of the secondary crestlines in the lee of the scarps, indicates that the latter act as point sources of sediment for the former, which can be viewed as a later generation of sand streamers. The sand streamers commonly detach from the upwind source, but may provide a particle source for abrasion and creation of a new down wind scarp. This accounts for the alignment of the scarps and secondary crestlines.

The sand streamer orientation is in agreement with the latest wind event, reflected by the ripples, but departs from the paleowind that gave rise to the main crestlines, which are being reworked (Fig. 3). The presence of fractures along the stoss of the sand streamers, ripple presence largely on their lee slopes, and the absence of dune development on the sand streamers, however, indicates that the streamers themselves are largely stabilized and that the overall sediment budget is limited. Sand in transport is probably concentrated along the surface of the sand streamers.

Stages of development: In addition to the two dune-forming events apparent in the current dune field, cross-strata visible in the interdune areas indicate a previous dune constructional event [4]. The cross-strata are not clearly related to the current dune field, which suggests that this is a deflational sequence surface capping an older constructional aeolian event. The current dunes represent a renewal of aeolian construction upon this surface.
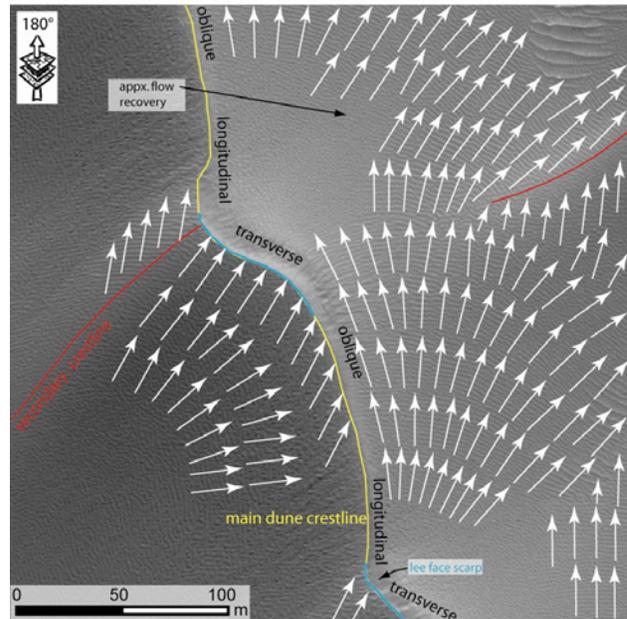
Figure 4.

Figure 4. Inset from Figure 2. White arrows indicate flow fields inferred from ripples.

In terms of the sediment state concept [5], the main crestlines probably represent contemporaneous and lagged influx within a dry aeolian system that was transport limited (i.e., at the capacity of the wind). In contrast, the secondary crestlines (i.e., sand streamers) formed in the modern availability-limited system.

References: [1] Tanka et al., (2008) In Planetary Dunes Work Shop: A Record of Climate Change, p. 69, LPI Cont. No. 1403. Lunar and Planetary Institute, Houston, TX. **[2]** Sweet, M.L. and Kocurek, G., Sedimentology, 37, 1023-1038. **[3]** Bourke, M.C. et al., JGR, 109, E07005, doi: 10.1029/2003JE002155 **[4]** Szynkiewicz, A. LPSC 2009 (*this volume*). **[5]** Kocurek, G. and Lancaster, N., (1999) Sedimentology, 46, 505-515.