BOUNDARY CONDITION CONTROL ON HIGH SAND FLUX REGIONS OF MARS. M. Chojnacki[1], M. E. Banks[2,3], and A. C. Urso[1]. [1]Lunar and Planetary Lab, University of Arizona, Tucson, AZ (chojan1@pirl.lpl.arizona.edu); [2]Planetary Science Institute, Tucson, AZ; [3]NASA Goddard Space Flight Center, Greenbelt, MD.

Introduction and Motivation: Environmental boundary conditions such as wind regime, topography, sediment supply, and sediment state are important factors that dictate how aeolian systems evolve and persist. For Earth, antecedent conditions like near-surface water tables and vegetation can critically influence local bedform patterns and mobility [1]. Although some terrestrial factors may apply on Mars, many do not (e.g. vegetation). Alternatively, more unique martian boundary conditions, such as hosting crater morphology, can influence a dune field's characteristics [2, 3]. Recognizing these controlling factors may provide insight into landscape evolution on Mars as aeolian processes have likely dominated there for most of its history, in contrast to the Earth where aqueous processes are prevalent. Recent efforts from surface and orbital assets have revealed winds are frequently transporting fine-sediment across the surface of Mars today as observed with migrating aeolian sand ripples and dunes [for a review see 4]. These results include geographic variations in bedform transport parameters, which are important indicators that relate to climate, surface erosion, and landscape evolution [2, 4–8].

Here, we investigate and quantify dune migration trends across Mars, utilizing temporal image series and topography. In particular, this abstract intends to explore boundary conditions on Mars and their role controlling sand movement. Related questions include: What regions possess the highest sand transport rates and what are the boundary conditions that govern those regions? Are there any consistent factors from region to region? How does this knowledge inform our understanding of landscape evolution on Mars?

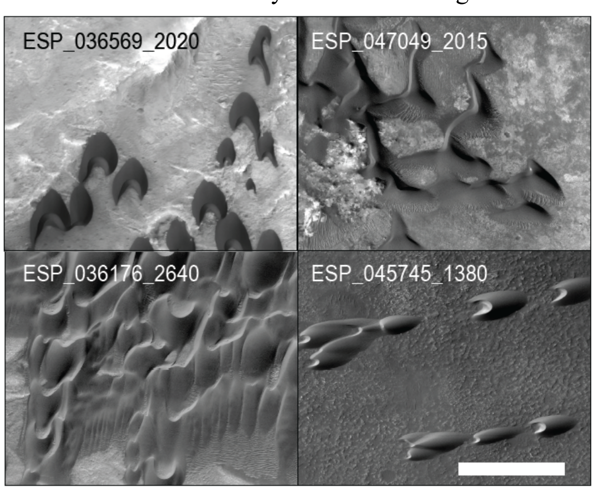

Figure 1. HiRISE images of high-flux dune fields in (clockwise from upper left): Mawrth Vallis, Nili Fossae, Olympia Undae, and Hellespontus. White scale bar is 500 m and all panels are at the same scale.

Data Sets and Methods: To assess aeolian activity, we have utilized images acquired by the High Resolution Imaging Science Experiment (HiRISE) camera (0.25–1 m/pix). For image orthorectification and dune topography, Digital Terrain Models (DTMs) (at 1 m post spacing) were constructed from HiRISE stereo pairs. Lee front advancements were recorded in several locations per dune, then averaged. Volumetric sand fluxes of the dunes can be obtained using the product of the estimated height and the bedform displacement over the intervening time (typically 2–3 Mars years), producing units of m^3 m^{-1} yr^{-1} in time units of Earth years. See [2] for full methodology. Regional thermal and elevation properties were derived from TES and MOLA data, respectively.

Results: Prior analysis has provided the global distribution of active bedforms and their transport parameters [5–8]. Sand dune crest fluxes are in the range of 0.8-17.6 m^3 m^{-1} yr^{-1} while individual dunes may exceed 25 m^3 m^{-1} yr^{-1}. The average and standard deviations for all sites investigated are 6.5+/-4.9 m^3 m^{-1} yr^{-1}.

Moderate- and high-flux regions (defined here as >5 and >12 m^3 m^{-1} yr^{-1}, respectively) occur with detections of dune fields in four different regions: the west of Mawrth Vallis, Syrtis Major, Olympia Undae, and Hellespontus Montes (**Fig. 1-2**). These occur with variable sized dunes, typically barchan or barchanoid morphology, found in a variety of environments: craters, fossae, patera, polar basins, and extracrater terrain. However, in all cases these regions are located near large topographic dichotomies: Mawrth Vallis southeast of the global dichotomy, Syrtis Major west of the Isidis Basin, Olympia Undae adjacent to the North Polar cap, and Hellespontus west of the Hellas Basin (**Fig. 2**). Dune migration vectors and other aeolian wind indicators (e.g. slipfaces, wind streaks) tend to conform to a general direction per region. Transport directions are broadly aligned and parallel to regional-scale slopes, but may occur downslope or upslope consistent with katabatic and anabatic wind regimes, respectively. However, these are not mutually exclusive as Syrtis and Hellespontus dunes show evidence for seasonally reversing flow. All four regions show albedo variations across their dichotomies, varying 10% to 20%. As one would expect with this, TES also indicates notable surface temperature variations.

Discussion: All four regions deserve additional considerations to their unique boundary conditions.

West Mawrth – Dispersed craters across Arabia Terra-Meridiani, including locations on the dichotomy like McLaughlin crater, possess dominantly southward migrating dunes [2, 3]. This indicates that a northerly wind regime drives most regional sediment transport, although dune-forming sand appears relatively limited. Dune fluxes are greatest closer to the dichotomy and decrease farther southeast. These northern-most craters have relatively flat-floors, whereas craters farther south often show km-scale topographic obstructions (e.g. central peaks) that appear to depress sand mobility [2]. Regional crater floor deposits, thought to be sedimentary, often lack small craters implying some steady erosion is occurring (~1 m/Myr) [9]. Even relatively low flux dunes like those found in Becquerel crater (**Fig. 2**) can account for such resurfacing rates [10], so higher flux zones in nearby Mawrth are likely experiencing higher erosion rates.

Syrtis Major – Regional dunes here are found in a variety of contexts, but are strongly influenced by their proximity and direction to the Isidis Basin. Anabatic slope winds appear to cause the migration of dunes radially from the basin center. The influence of westward winds can be observed with dunes across the plains above Jezero crater, deep within Nili Fossae, and even as far as Nili Patera where high flux dunes are located [4, 8]. Some of these bedforms have been estimated to produce relatively high abrasion rates (~0.1–50 m/Myr), given some basic assumptions [4, 8], which likely contribute to local landscape evolution. Like tropically-located Mawrth, sand is unconsolidated and not influenced by a seasonal volatile cycle.

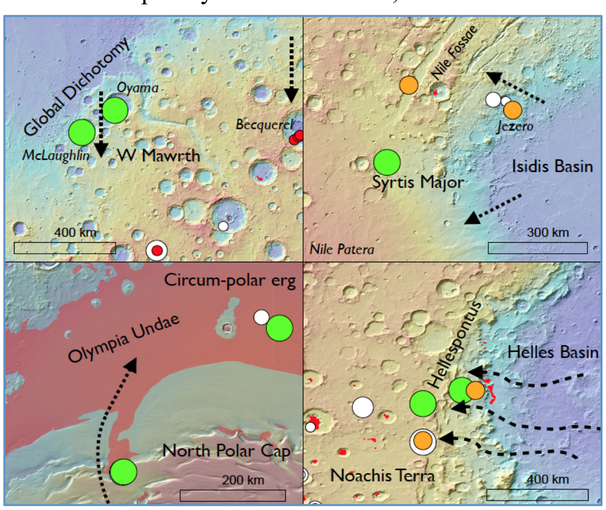

Figure 2. Study regions where graduated circles represent high- (green), moderate- (orange), and low- (red) flux dunes fields and white circles show ripple rate results. Wind directions (arrows) were inferred from migration directions and morphology. Dune field distribution is shown in red [3] and base map is MOLA shaded relief colorized with elevation (blue is low, red high). Also see [5-8].

Olympia Undae – Arguably the most active dune region on Mars, the north circum-polar erg also has the highest sand supply with the polar deposit basal unit as the primary sand source. One important boundary condition here is the seasonal CO_2 frost and ice that covers the erg prohibiting migration for roughly half of the year. Despite this, the region shows extensive year-to-year activity with ripple and dune migration [4, 5, 11]. Slipface alcove formation is partially caused by seasonal ice deposition, stabilization, and sublimation, contributing to up to 20% of the local sand movement [11], a factor that does not influence terrestrial dunes. Mesoscale models indicate spring and summer katabatic winds are driven by the retreat of the seasonal CO_2 and are fastest at the polar cap boundary [12], where some of the highest sand fluxes have been measured.

Hellespontus – This region shows numerous intra- and extra-crater dune fields with the highest flux areas along the rugged rim elements of western Hellas. Similar to the Syrtis-Isidis relationship, dunes appear to be driven by Hellas Basin anabatic slope winds. Further west and south in Noachis Terra, sand fluxes and mobility decrease. Sites south of 57°S are often static or only produce modest ripple movement. This effect has been attributed to a poleward increase in seasonal volatiles as a stabilization factor [6, 13], which draws a stark contrast to the north polar volatile cycle which appears to increase sand transport.

Conclusion: Very different boundary conditions control the diverse high sand flux regions of Mars. All locations are near large topographic dichotomies, which also have strong thermal gradients that likely contribute to seasonal winds and in turn high sand fluxes. Seasonal volatiles at higher latitude sites may play a critical role for inhibiting or contributing to sand mobility. Future efforts will be employed to test whether a geomorphic signature can be observed on the underlying landscapes of these high flux regions (e.g. paucity of small craters).

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