THE SEDIMENT STATE OF MERIDIANI PLANUM, MARS. L. K. Fenton[1], T. I. Michaels[1], and M. Chojnacki[2], [1]SETI Institute (189 Bernardo Ave, Ste. 100, Mountain View, CA 94043, USA, lfenton@seti.org), [2]Lunar and Planetary Lab (University of Arizona, Tucson, AZ 85721, USA).

Introduction and Background: A fundamental control of bedform field accumulation is the sediment state, which is governed by three factors: the sediment supply, the sediment availability, and the transport capacity of the wind [1]. The sediment supply is defined as the volumetric influx rate of source material into an aeolian system (e.g., river sediments, volcanic ash). Sediment availability is the degree to which the sediment supply's is inhibited (e.g., it is reduced when the sand is cemented, vegetated, or buried). The wind's transport capacity is its sediment-carrying capacity (e.g., a strong wind transports more sand than a weak wind). The ***sediment state*** at any point in an aeolian system's history is determined by 1) which of these three components limits aeolian sediment flux and 2) whether the sediment supply is/was contemporaneous (e.g., actively eroding from a lakebed), lagged (e.g., reworked from older bedforms), or both.

Making some assumptions about bedform development in Meridiani Planum, it is possible to qualitatively determine the sediment state of the plains during the Late Amazonian, to the extent revealed by the visible bedforms [2]. This analysis does not include dark intracrater dune fields (e.g., [3,4]). These dunes represented a sediment state different from that on the plains; they are modified by a wind regime heavily influenced by the crater topography (affecting the wind transport capacity) and are likely less indurated than the plains bedforms (affecting sediment availability).

Bedform construction: The following describes three sets of superposed bedforms found on the plains and on the floors of small (<200 m) craters.

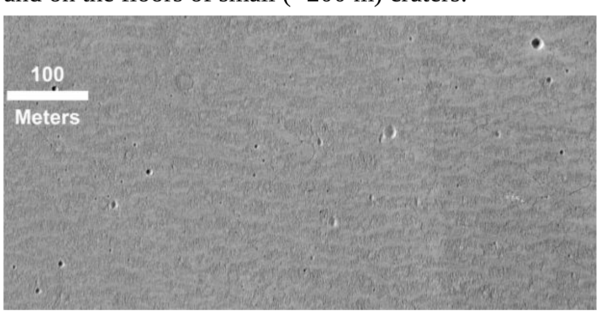

Figure 1. E-W bedforms first identified by [5]. These are the oldest known bedforms on the plains.

E-W bedforms. Figure 1 shows a set of ~15-m-wavelength structures on the plains that are aligned east-to-west (E-W). Because they are sub-parallel, have positive relief (~1-1.5 m), and often terminate in Y-junctions, they were interpreted as bedforms [5]. Little is known about these features, but they are superposed by plains ripples, and therefore they must at minimum predate the last known plains ripple migration, dated to 50-200 ka by [6].

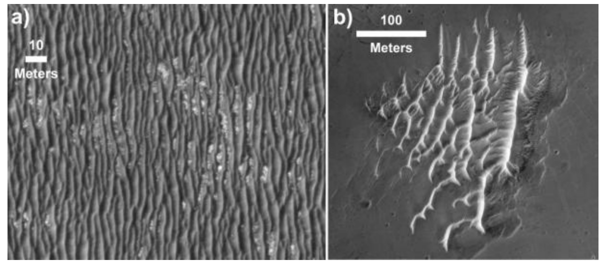

Figure 2. N-S bedforms, including a) plains ripples and b) some elements of intracrater TAR fields.

N-S bedforms. North-to-south (N-S) aligned plains ripples (Fig. 2a) and west-oriented ripple streaks [2, 7] were formed by a strong (u_* = 2.5-3.5 m/s [8]) unimodal easterly wind (~092.5°) that was directionally uniform throughout the study area. One of two modal intracrater Transverse Aeolian Ridge (TAR) crestline sets is also oriented N-S (Fig. 2b), which suggests that the TARs and plains ripples may be coeval. Atmospheric modeling and observations of present-day activity suggest this easterly wind no longer dominates sediment transport in the region [9,11].

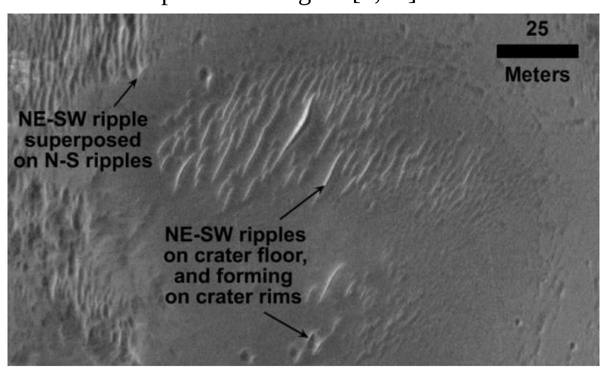

Figure 3. NE-SW bedforms, which are always found superposed on other surface features.

NE-SW bedforms. A number of relatively young bedforms are aligned northeast-to-southwest (NE-SW). This includes ~3-5-m-wavelength ripples found on the floors of small (<200 m) craters (Fig. 3), the second of two modal intracrater TAR crestline sets (Fig. 2b), and relatively young ripples superposed on the plains ripples traversed by Opportunity [10]. These bedforms overlie other features in Meridiani Planum, including N-S plains ripples and crater ejecta from an 0.84 km crater dated by [6] to 50-200 ka.

Modern aeolian landforms. Mobile sand streaks, dust streaks, and sand dunes (not shown) indicate that present-day sand transport is dominated by both northwesterly and southeasterly winds [3,4,8,10,11,12]. Although sand can be transported by these winds, it is not strong enough to mobilize the N-S plains ripples, nor does it match the NE-SW superposed ripples.

Sediment state:

Sediment supply. Basaltic sand and hematite granules on the plains consist of both contemporaneous grains (those slowly eroding from the Burns Fm.) and lagged grains (those currently stored inside inactive bedforms and crater fill). Figure 4 shows that the sediment supply (red line) is constant but very low, representing the slow erosion of the plains. [5] proposed the plains sand was derived from an overlying sand-rich layer that has since eroded away; in that case the sediment supply would instead be represented as a flux pulse predating the E-W bedforms >>~200 ka.

Sediment availability. Both coarse grains [8] and particle cohesion [10,13] limit sediment mobility. These factors are unlikely to change over time, unless winds become strong enough to overcome the higher stress thresholds required to transport larger grains and destroy cohesive crusts. Figure 4 shows sediment availability (green dotted line) as lower than the sediment supply, except in the rare cases in which the wind transport capacity exceeds the transport threshold.

Wind transport capacity. Wind stresses are thought to vary with orbital cycles [14]. Extended periods of high wind stress are required to construct the observed bedforms, with larger bedforms typically requiring longer or more extreme windy conditions. Figure 4 shows a proposed wind transport capacity history (black dashed line), with three episodes of decreasing intensity that correspond to the construction of the E-W, N-S, and NE-SW bedforms. Not included in Fig. 4 is the (perhaps ongoing) construction of the intracrater dune fields.

Conclusions: The preserved surface record from the Late Amazonian in Meridiani Planum consists of four potential periods of bedform construction. The most recent three periods can be represented by an easterly wind gradually giving way to a relative strengthening of northwesterly and southeasterly winds. Based on observations, we propose a scenario describing the sediment state of the plains with conditions alternating between transport-limited contemporaneous and lagged sediment influx (CLI_{TL}, gray in Fig. 4), during which bedforms are constructed, and relatively long periods (including the present-day) of availability-limited contemporaneous sediment influx (CI_{AL}, light green in Fig. 4).

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References: [1] Kocurek and Lancaster (1999), doi:10.1046/j.1365-3091.1999.00227.x. [2] Fenton et al. (2015) doi:10.1016/j.aeolia.2014.11.004. [3] Chojnacki et al. (2015) doi:10.1016/ j.icarus.2014.04.044. [4] Chojnacki et al. (2015), this mtg. [5]. Silvestro et al. (2014) *8th Int'l. Mars Conf.* http://www.hou.usra.edu/meetings/8thmars2014/eposter/1193.pdf. [6] Golombek et al. (2010) doi:10.1029/2010JE003628. [7] Silvestro et al. (2014) *XLV LPSC*, Abst. #1887. [8] Jerolmack et al. (2006) doi:10.1029/2005JE002544. [9] Chojnacki et al. (2011) doi:10.1029/2010JE003675. [10] Sullivan et al. (2005) doi:10.1038/nature03641. [11] Michaels et al. (2015), this mtg. [12] Geissler et al. (2010) doi:10.1029/2010JE003674. [13] Sullivan et al. (2008) doi:10.1029/2008JE003101. [14] Haberle et al. (2003) doi:10.1016/S0019-1035(02)00017-9.

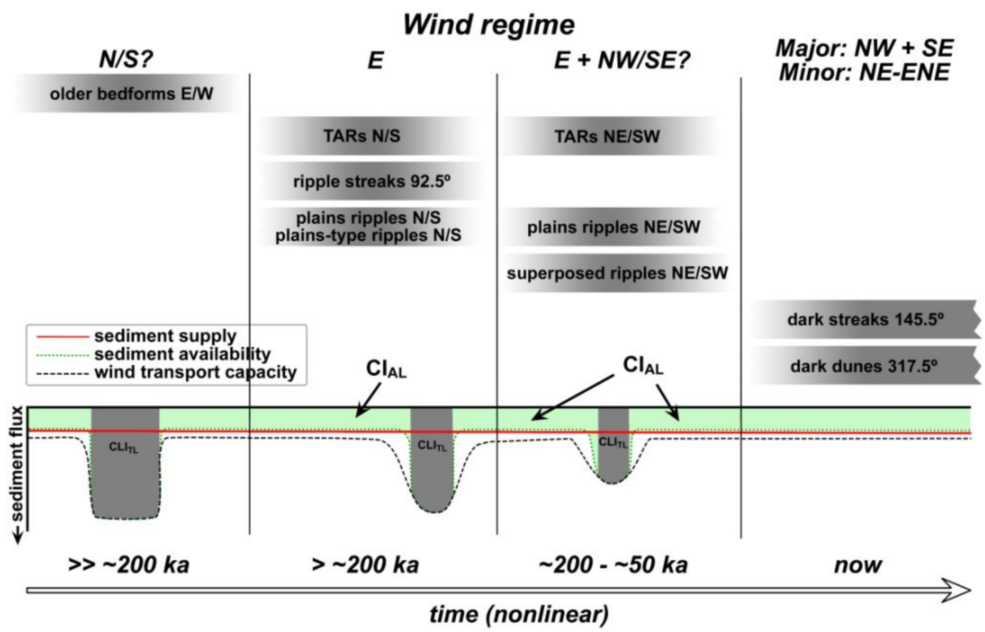

Figure 4. Proposed sediment state of Meridiani Planum