THREE-DIMENSIONAL DOCUMENTATION OF THE TRANSITION FROM SAND RIPPLES TO MEGARIPPLES. J. R. Zimbelman[1], S. P. Scheidt[2], M. M. Baker[1], E. Williams[3], [1]CEPS/NASM, MRC 315, Smithsonian Institution, Washington, DC 20013-7012, zimbelmanj@si.edu; [2]Planetary Science Institute, Odenton, MD 21113; [3]Department of Geology, University of Maryland, College Park, MD 20742.

Introduction: The transition from sand ripples to megaripples encodes information about the physics of how both sand-sized (moved via saltation) and coarse-grained (moved via impact creep) particles interact under Martian conditions. Previous studies have focused on the aeolian mobility of sand on Mars; here we examine how mobile sand interacts with larger particles moved by creep. HiRISE images of small dunes (lacking well developed slip faces) on Mars reveal a transition of aeolian bedform scale with increasing distance from the dune [1]. Here we document the particles in a similar transition on Earth.

Background: High Resolution Imaging Science Experiment (HiRISE [2]) images have documented that sand is moving at many locations around Mars under current conditions [3-5]. Unlike the active sand deposits, enigmatic "Transverse Aeolian Ridges" (TARs; the non-genetic term for linear to curvilinear aeolian bedforms resulting from either dune- or ripple-forming processes [6]) are found at locations widely distributed across Mars [7-9]. Recently bright TARs were documented to have moved in HiRISE images taken many Earth years apart at three widely separated locations [10]. Great Sand Dunes National Park and Preserve (GSDNPP) in Colorado [11] has a bimodal particle size distribution along with a seasonal bimodal wind regime, providing the setting to examine the transition from sand ripples (<1 cm in height) to megaripples (typically ~25 cm in height).

Results: A Smithsonian Scholarly Studies Award for FY19 funded trips to GSDNPP during May and September of 2019 to collect thousands of digital photographs of ripple-megaripple transitions that were later processed using Multiview Stereo Photogrammetry software to produce detailed Digital Terrain Models (DTMs; Fig. 1). The digital images were obtained using a Nikon camera that was motor-driven along a track above the study area. The track was then manually advanced following each photo traverse. Photos were obtained using both a 35 mm lens and a 85 mm Macro lens. The DTMs clearly resolve individual coarse (1-2-mm diameter) particles on the bedforms, providing a detailed record of the surface distribution of coarse grains across both sand ripple and megaripple bedforms, including cases where the crests were continuous between sand ripples and megaripples. Trenching of bedforms revealed that often both sand ripples and megaripples are coated by a layer of coarse particles that become increasingly more closely packed approaching the crest of the bedform. Coarse grains are stacked several particles deep at the crests of megaripples, a condition common on many megaripples [e.g. 12, 13]. Under strong (>8 m/s at 50 cm above the surface) wind conditions, we observed coarse particles to either roll or move several millimeters when impacted by saltating sand.

We did not observe that sand ripples are a necessary prerequisite for the initiation or growth of megaripples, but the two bedform scales do interact because the rate of bedform movement is proportional to bedform height [14], so that sand ripples overtake the larger megaripples. The spatial density of coarse particles does appear to influence the growth of ripples, when the coarse particles become so closely packed that the underlying sand is no longer exposed to saltating sand. We intend to explore this relationship quantitatively as more DTMs become available.

Application to Mars: There is abundant evidence from rover images that ripples of multiple sizes and wavelengths are common on Mars [15-18]. Curiosity images include many examples of interactions between sand ripples and megaripples (Fig. 2). In order to assess ripple-megaripple transitions observed from orbit, a project during the summer of 2019 examined three HiRISE images covering portions of Nirgal Vallis, a sapping channel whose floor is covered by TARs [19]. We documented ripple-megaripple transitions with continuous crests at one-fifth of TAR crest terminations, out of 1570 terminations examined in the three images. Additionally, 1/3 of the TAR crest terminations had 'probable' transitions, so that less than half of TAR crest terminations had no evidence of a transition.

References: [1] Zimbelman, J. R. (2019) Icarus 333, 127-129, doi: 10.1016/j.icarus.2019.05.017. [2] McEwen, A.S., et al. (2007) JGR-Planets 112, E05S02, doi: 10.1029/2005JE002605. [3] Silvestro, S., et al., (2010) GRL 37, L20203, doi: 10.1016/ j.icarus.2019 05.017. [4] Bridges, N., et al. (2012) Geology 40, 31-34, doi: 10.1130/G32373.1. [5] Banks, M. E., et al. (2018) JGR-Planets 123, 3205-3219, doi:10.1029/2018 JE005747. [6] Bourke, M.C., et al. (2003) LPS XXXIV, Abs# 2090. [7] Wilson, S. A., J. R. Zimbelman (2004) JGR-Planets 109, E10003, 10.1029/2004 JE002247. [8] Balme et al., 2008. [9] Berman et al., 2011, 2018. [10] Silvestro, S., et al. (2019) LPS L, Abs# 1800. [11] Madole, R. F., et al. (2008) Geomorph. 99, 99-119. [12] Sharp, R. P. (1963) J. Geol. 71, 617-636. [13] de Silva, S. L., et al. (2013) GSAB 125 (11/12), 1912-1929, doi: 10.1130/B30916.1. [14] Bagnold, R. A. (1941) The physics of blown sand and desert dunes. Chapman and Hall, London. [15] Sullivan, R.S., et al. (2005) Nature 436, doi: 10.1038/nature 03641. [16] Sullivan, R. S., et al. (2008) JGR-Planets 113, E06S07, doi:10.1029/2008JE003101. [17] Lapotre, M. G. A., et al. (2018) GRL 45, 10,229-10,239, doi: 10.1029/2018GL079029. [18] Baker, M. M., et al. (2018) GRL 45, 8853-8863, doi: 10.1029/2018GL07 9040. [19] Reiss, D., et al. (2004) 109, E06007, doi: 10.1029/2004JE002251.

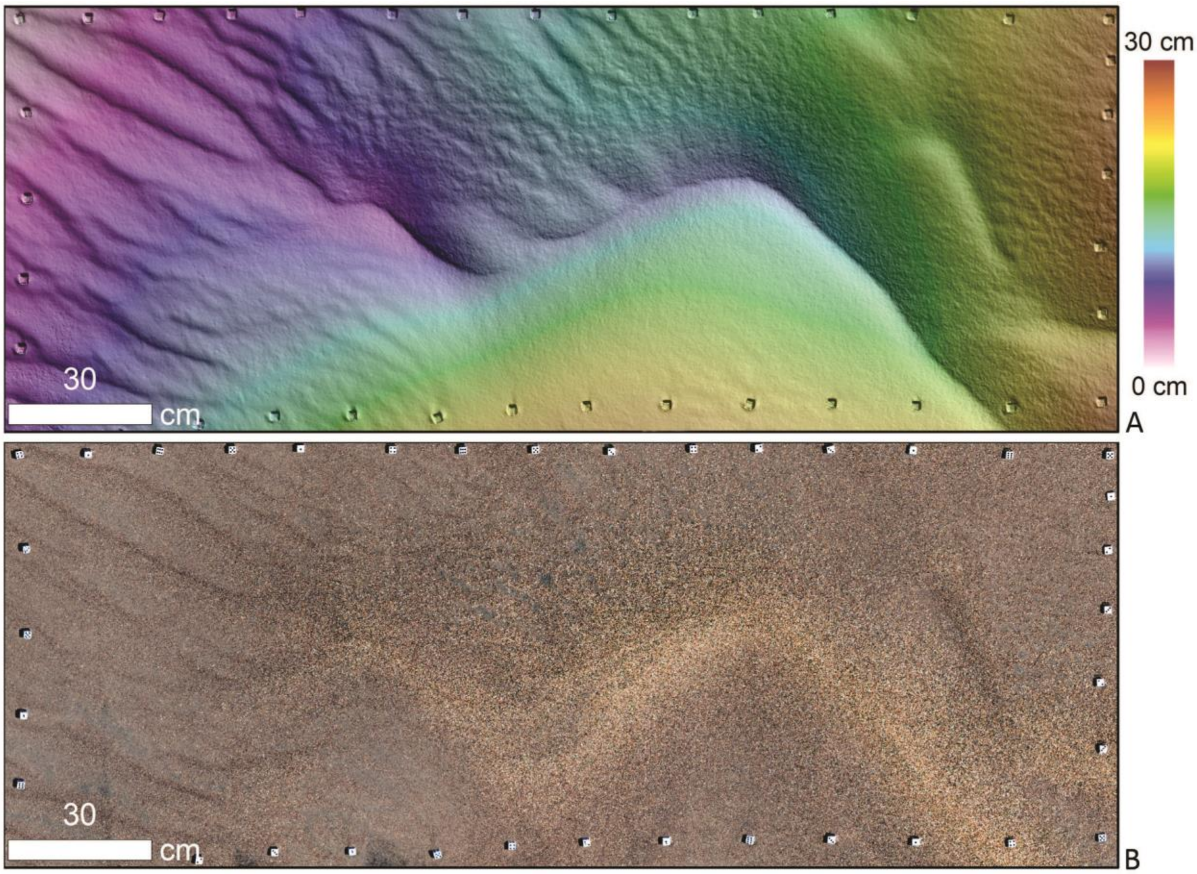

Figure 1. Study area at GSDNPP, outlined by dice. A) DTM of one study area. Site slopes 11° to S30E, so height here increases relative to 0 at upper left. B) Orthophotomosiac corresponding to area shown in part A.

Figure 2. Example of ripple-megaripple interactions in a Curiosity Mastcam mosaic, Enchanted Island, sol 1752. NASA/JPL-Caltech/MSSS. [From Fig 1d of 17].