CHARACTERIZING THE MOBILITY OF MEGARIPPLES ON MARS. S. Silvestro[1,2], M. Chojnacki[3], D. A. Vaz[4], & A. Botteon[5]. [1]INAF Osservatorio Astronomico di Capodimonte, Napoli, Italy (simone.silvestro@inaf.it); [2]SETI Institute, Mountain View, CA; [3]Planetary Science Institute, Lakewood, CO; [4]Centre for Earth and Space Research of the University of Coimbra, Coimbra, Portugal; [5]Università G.D'Annunzio, Chieti-Pescara, Italy.

Introduction and study areas: Sand ripples on Mars cover a wide range of sizes and morphologies and are generally distinguished in two main classes: 1) dark-toned ripples (DTRs), 1–5-m spacing and ~40-cm tall and 2) bright transverse aeolian ridges (TARs), 10–100-m spacing and 1–14-m tall [1, 2]. Recently, an intermediate class of ripples 5–40-m spacing, ~1–2-m tall, have been reported to move on Mars (Fig. 1a) [3-5]. These bedforms were called "megaripples" (MRs) or "TAR-like megaripples" due to their similarity to bright-toned TARs [4, 5]. Here we analyze two sites in McLaughlin crater and Ganges Chasma where active and static megaripples co-exist with mobile dunes. We compute the fluxes for MRs and dunes and we check for potential relationships between bedform fluxes and topography at the HiRISE scale. This effort seeks to constrain factors that promote or limit mobility for these bedforms.

Methods: Dune and megaripples movement were measured by tracking bedform crestlines within HiRISE images in a GIS environment. Fluxes are derived by multiplying bedform migration rates by their heights [6]. Dune heights are derived from HiRISE DTMs [7] while for the ripples we used the wavelength vs. height relation employed by [8]. Flux computations are refined using a co-registration algorithm, which computes the bedrock apparent displacements and corrects the location of the advancing crest lines. DTRs migration over dunes in Ganges Chasma is tracked with COSI-Corr [8].

McLaughlin crater: McLaughlin is a 92-km-diameter crater with a depth of 2.2 km. A field of barchan dunes is accumulated on the crater's southern floor over the ejecta of Keren crater [9, 10]. Dark-toned ripples are visible over the dunes while megaripples are generally brighter (Fig. 1a). Here we refine previous MRs flux estimations [4] with the co-registration algorithm described above and applied to an image pair with an increased 2008-2021 time-range. Of the 36 MR areas analyzed in [4], movement is not confirmed in two. This includes the area shown in Fig. 7b in [4]. MRs are generally found in continuity with DTRs and dune sands but locally such a relationship might be hard to discern [4, 5] (Fig. 1a). This is mainly due to two reasons: 1) dark sands are locally infilling MRs crest [4], and 2) active MRs are moving over static ones both possessing similar albedo (Fig. 1a dashed oval). Bedforms shown in Fig. 9 in [4] might represent examples of this situation. Updated median MRs flux is 0.016 ± 0.01 m^2/yr, two order of magnitude lower than dune fluxes (Fig. 1b). These results are consistent with earlier reported dune/MR flux ratios for other areas on Mars (e.g., Nili Fossae and Buzzel [4, 5]).

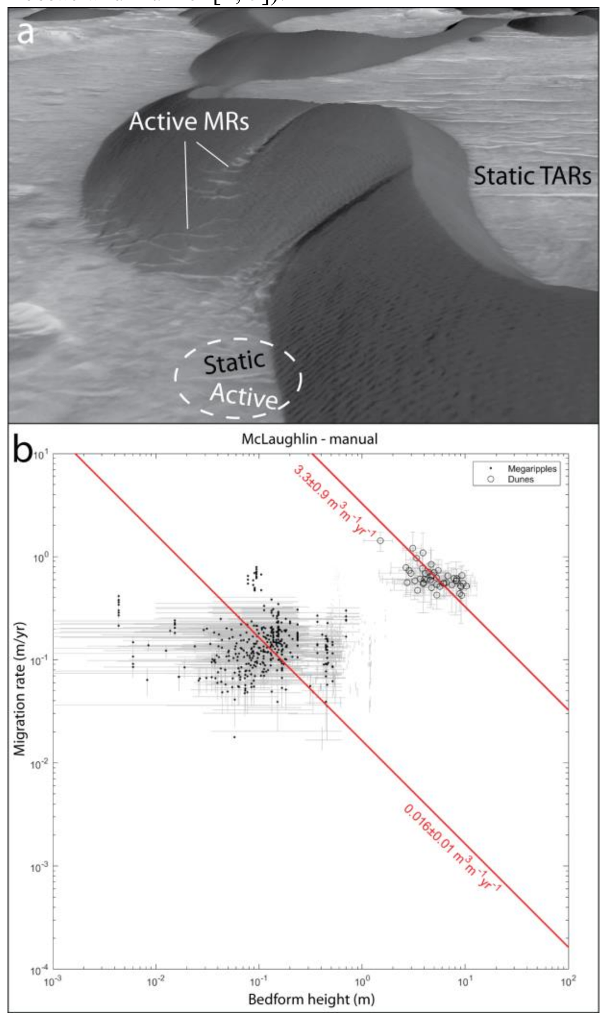

Fig. 1. a) 3D view of aeolian bedforms in McLaughlin crater where active and static MRs and TARs locally interact to form Y junctions - dashed white oval (HiRISE PSP_009814_2020 on HiRISE DTM) b) Dunes (ovals) and MRs (dots) flux comparison computed over HiRISE orbits PSP_009814_2020 and ESP_071885_2020.

Ganges Chasma: This dune field is located at the foot of the Ganges Chasma northern wall, in a complex topographic context [11, 12]. Like other dune fields on Mars, it consists of barchan and barchanoid dunes transitioning downwind to a sand sheet (Figs 2 and 3) [11-12]. DTRs cover the dark dunes and the sand sheet. Together with dunes and DTRs, TARs and MRs are also visible (Fig. 2). By comparing two HiRISE images, overlapping in the northern portion of the field, we can distinguish two sets of TARs/MRs, active and static ones (Fig. 2). The two bedform sets have similar wavelengths and albedo, where the immobile variety are located stratigraphically below mobile sand elements (Fig. 2). Median MRs fluxes measured over the 2008-2017 time range (MY 29-35), is 0.14 ± 0.07 m^2/yr, one order of magnitude lower than median dune fluxes. This is the highest flux measured so far for this type of bedform. Dune fluxes are decreasing downwind but topographic effects can be better appreciated by looking at the COSI-Corr spatially averaged DTRs migration magnitudes over the 2017-2019 time-span (Fig. 3).

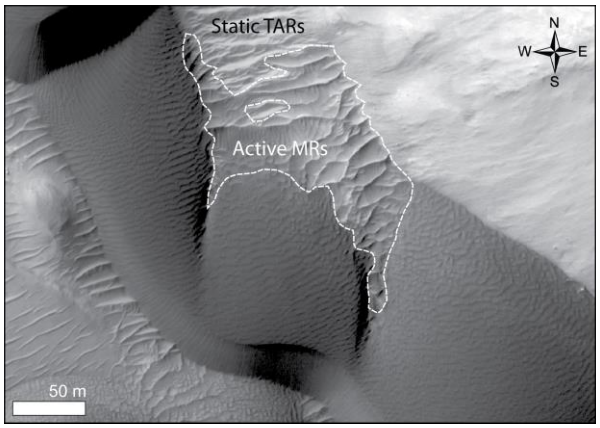

Fig. 2. Dunes and MRs in Ganges Chasma (see Fig. 3 for location). Active MRs are found on top static TARs. Locally, such a relationship might be hard to discern (dashed line). HiRISE ESP_053409_1725.

Discussion: In McLaughlin and Ganges both active and static bright-toned ripples coexist with active sand dunes. This suggests a different degree of cementation/crusting for the different MR populations. This scenario appears to be common on Mars (See GIF 1 from Nili Fossae [4] and bedforms in Jezero [13]). In general, active MRs overlie static ones and are in continuity with dune sands. If a difference exists between megaripples and TARs [14, 15], the highlighted stratigraphic relationship might be used to distinguish between these two types of bedforms. In McLaughlin MRs flux contribution to the total system is analogous to other areas [5] while in Ganges MRs flux is one order of magnitude higher. Despite a sampling bias is certainly playing a role (only the upwind/faster MRs are investigated here with the dune fluxes being highly variable in the area ranging from 2 to 10 m^2/yr), Ganges MRs are slightly larger leading to higher fluxes. Topographic forcing of the atmosphere is certainly playing a role in displacing these large MRs with canyon downslope winds diverting around obstacles and driving MRs migration (Fig. 3). Combining migration and flux estimates for different types of aeolian bedforms with topographic data from HiRISE is crucial to test atmospheric models and to build adequate models for sand transport on Mars [12, 13, 16-18].

Acknowledgments: This research was supported in part by NASA MDAP Grant 80NSSC21K1096. D. V. acknowledge CITEUC's support (UID/Multi/00611/2020).

References: [1] Bridges N. et al. (2007) GRL, 34, L23205 [2] Zimbelman J. et al. (2013) Aeol. Res., 11, 109-126 [3] Chojnacki M. et al. (2019) Geology, 47, 5, 427-430 [4] Silvestro S. et al. (2020) JGR, 125, 8 [5] Chojnacki M. et al. (2021) JGR, 126, 12 [6] Chojnacki M. et al. (2018) JGR, 123, 2, 468-488 [7] Urso A.et al. (2018), JGR, 123, 2, 353-368 [8] Bridges N. et al. (2012) Nature, 485, 7398, 339-342 [9] Michalski J.R. et al. (2013), Nat. Geo., 6, 2 [10] Michalski J.R. et al. (2019), JGR. 124, 2 [11] Chojnacki M. et al. (2014), Icarus, 230, 96-142 [12] Fenton L.K. et al. (2014), Icarus, 230, 47-63 [13] Sullivan et al. (2022), 53rd LPSC [14] Hugenholtz H. et al. (2017), Icarus, 286, 193-201 [15] Day M. & Zimbelman J. (2021), Icarus, 369, 114647 [16]) Vaz D. et al. (2017), Aeol. Res., 26, 101-116 [17] Urso A.et al. (2018), JGR, 123, 2, 353-368 [18] Roback K.R. et al. (2020), Icarus, 342, 113642

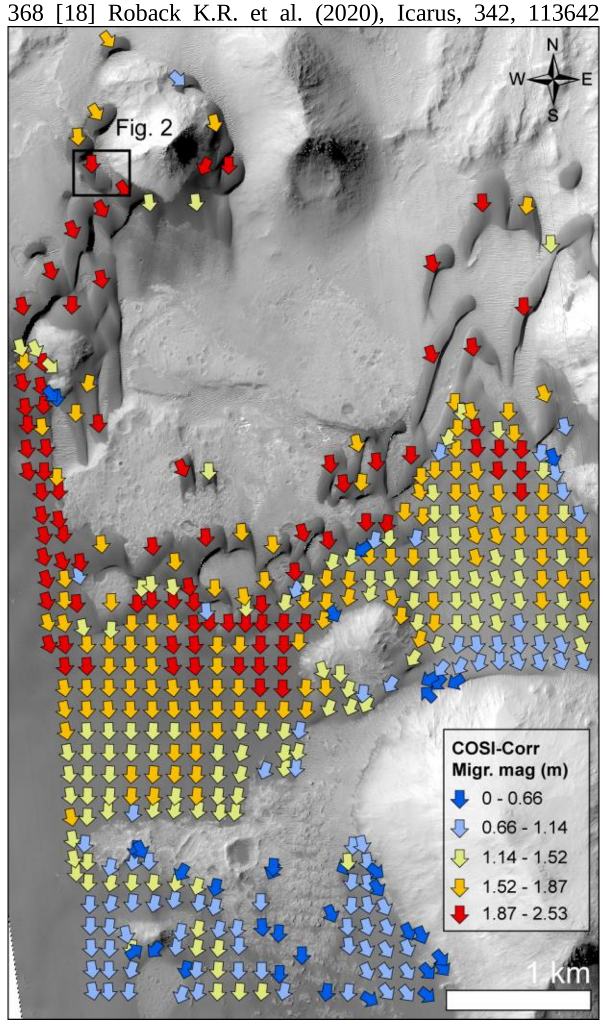

Fig. 3. COSI-Corr average migration vectors for the Ganges Chasma field obtained by comparing HiRISE ESP_053409_1725 and ESP_061638_1725. DTR migration magnitude was averaged per dune and over a 100-meter square on the sand sheet.