ACTIVE PROCESSES IN VALLES MARINERIS. M. Chojnacki[1], A. McEwen[1], C. Dundas[2], C. Hamilton[1], S. Mattson[1], and the HiRISE Team, [1]Lunar and Planetary Lab, U.A., Tucson, AZ, 85721 (chojan1@pirl.lpl.arizona.edu), [2]USGS, Astrogeology Science Center, Flagstaff, AZ.

Introduction and Motivation: The enigmatic Valles Marineris (VM) trough system exposes a ~10-km-thick section of martian crust with steep topography and abundant evidence for mass wasting [1]. The large atmospheric pressure gradient, potential energy, and availability of loose sediment contribute to the likelihood of active processes there.

Fine-scale repeat images from High Resolution Imaging Science Experiment (HiRISE) [2] onboard Mars Reconnaissance Orbiter (MRO) provide the opportunity to detect small surface changes in and around VM. These data, along with monitoring using other MRO, Mars Express (MEx), and Mars Global Surveyor (MGS) instruments, reveal fundamental new insights regarding the dynamic phenomena occurring there. Here, we describe the diverse near-surface and atmospheric processes which occur in the VM region at multiple temporal and spatial scales.

Slope Processes: The steep topography of VM invites a variety of different slope events.

• ***Recurring Slope Lineae (RSL):*** RSL are narrow, dark-toned streaks that occur on steep, low-albedo slopes and incrementally grow, fade, and reappear annually. They were initially detected in the mid-latitude southern highlands [3], but are now known to be especially abundant and active within low-albedo portions of eastern VM (**Fig. 1**) [4-5]. Their seasonal behavior and preference for warm equator-facing slopes suggests the involvement of a volatile, possibly briny water, an attractive explanation for this phenomenon [3-4]. However, the exact formation mechanism and source of the putative water remain elusive. Regardless, it is becoming clear that conditions within eastern VM are particularly favorable for the formation of RSL, as they are detected within diverse and widespread geologic environments (e.g., craters, landslide scarps, canyon walls, and possibly sand dunes) [5]. This diversity suggests a widespread process is creating the RSL there. Perhaps the combination of equatorial location, thermophysical properties (thermal inertia and albedo), and atmospheric phenomena (see below) create the conditions suitable for water seeps on the warm slopes of VM.

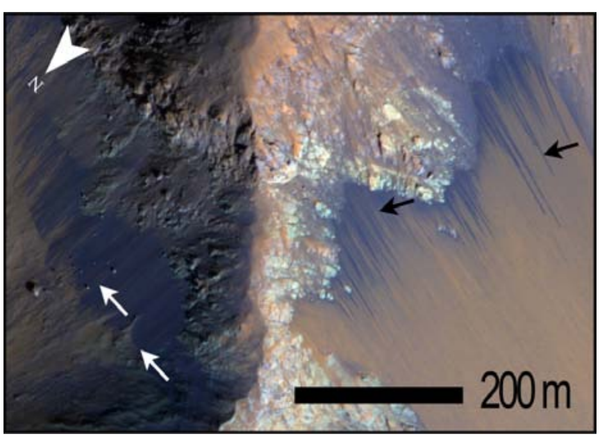

Figure 1. HiRISE enhanced color views of RSL forming on steep slopes in Coprates Chasma. Downslope is toward the bottom in all images. ESP_034830_1670. See http://www.uahirise.org/sim/ for animated VM RSLmovies.

• ***Mass Movement:*** Mass-wasting is ubiquitous across VM at multiple scales, from giant landslides to shallow gullies within wall units [1,6]. Boulder tracks, boulders, and larger lobes of talus commonly appear on steep slopes at or near the static angle of response (30°–40°) for many expected sediment sizes, implying that mass wasting of these materials is an ongoing process, and possibly geologically recent [4-7]. In examples where boulders and their tracks are found superposed on sand dune surfaces, this indicates mass-wasting has occurred after bulk dune construction and may be recent [8]. Additionally, there have been numerous small-scale slope changes detected by HiRISE, which resemble RSL, but without the incremental behavior and seasonality that favor volatile involvement [4]. One example of these possible dry mass-wasting events is shown in **Fig. 2**, where sediment trails down a steep layered deposit cliff edge. There are also abundant slope streaks interpreted as dust avalanches [9] in dust-mantled and high-altitude surrounding areas.

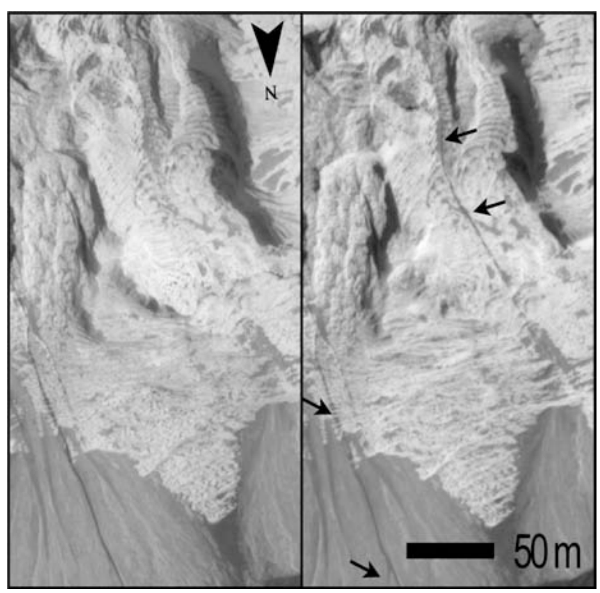

Figure 2. HiRISE detections of what are being interpreted as “dry” mass wasting events on layered deposits in Ganges Chasma. (Left) PSP_005886_1715 (2007) and (Right) ESP_034882_1715 (2014).

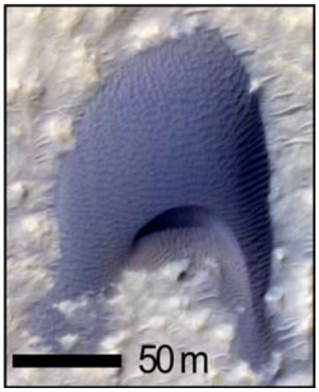

Figure 3. One of many Ganges Chasma barchan dunes, which was detected migrating at high rates of transport between 2008 and 2012 [8]. Dunes here were reported to translate ~5 m per Mars Year (2.7 m per Earth year) on average. ESP_026100_1725

Aeolian Processes: Many classes of wind driven events have been observed in and around VM.

• ***Active Aeolian Bedforms:*** VM hosts a diversity of dunes and lower-order bedforms associated with a variety of landforms and topographic contexts. Examples of detected aeolian driven bedform changes include: dune deflation, dune migration (**Fig. 3**), slip face modification (e.g., alcoves, streaks), and ripple modification or migration, at varying scales (10s–100s m^2) [8]. While similar to dunes elsewhere on Mars in detection frequency and migration rates [9], VM dune activity appears to occur over a greater elevation range and geologic context [8]. These events might be related to intense (20-40 m/s) katabatic winds that drain into the chasmata in the morning, inferred from mesoscale models [10-11].

• ***Dust Raising Events:*** Large-scale albedo variations, occurring over short (seasons) and long (~10 MY) temporal baselines, have been detected in the greater VM region, and ongoing monitoring is proving new insight [8,12-14]. For example, the historic albedo feature Solis Lacus (directly south of VM), varies in albedo on a nearly continuous basis, and is thought to be partially controlled by thin collections of discrete dust deposits originally sourced from the northwest (Tharsis) [12,14]. Active dust devils and their tracks are commonly reported in VM canyons and the surrounding region and are partially responsible for some albedo alteration [8,14-17]. Additionally, annual Thermal Emission Spectrometer (TES) bolometric albedos from MGS of VM and its dune fields vary significantly from Mars Year to Mars Year (~10-40%) over large areas (10s–1000s km^2). Negative changes in sand dune albedo may be partially brought on by saltation events (supported by HiRISE imaging) [8].

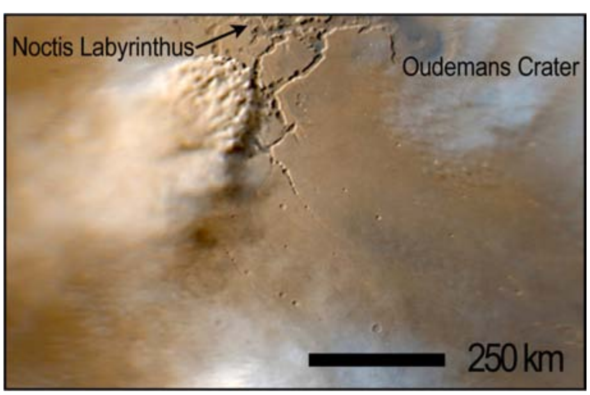

Figure 4. Distinctive cloud trails found in this MARCI view of southwest VM in 2011.

• ***Dust Storm Interactions****:* Both the 2001 and 2008 global dust storms substantially interacted with VM system [18-20]. During these storms, multiple regional dust storm tracks intersected with VM (e.g., Syria-Claritas storm system) where variable-altitude dust clouds were observed to obscure the troughs entirely [18-19]. In response, regional and inter-canyon surface albedos increased, as noted in multiple data sets [8,12].

• ***Dust Cloud Trails*****:** Using data from the wide-field Mars Color Imager (MARCI) camera [21] onboard MRO, *Clancy et al.* [22] discovered large scale, annual recurring cloud trails emerging out of VM (**Fig. 4**). These distinctive features form in multiple locations across the rift (e.g., Eos Chasma, Noctis Labyrinthus) and are interpreted as high-velocity (up to 40 m/s) thermally driven updrafts formed along canyon walls composed of dust and water ice particles [22].

• ***Clouds and Fogs:*** MEx has the ability to monitor the surface at times of day not observed since Viking. With this ability, onboard instruments have helped characterize long lived (3-7 sols), early morning, bright hazes (dust with minor water ice) within the canyon which form in the Northern Spring [23]. As with dust cloud trails described above, how these fogs interact with the surface and relate to other described phenomena above is unknown.

Summary: Information gained from multiple orbital platforms operating over sustained periods have revealed VM to be one of the most dynamic regions on Mars. Future monitoring of VM and other active regions on Mars will greatly aid in understanding how Mars' climate has evolved to its current state and the mechanisms behind such change.

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