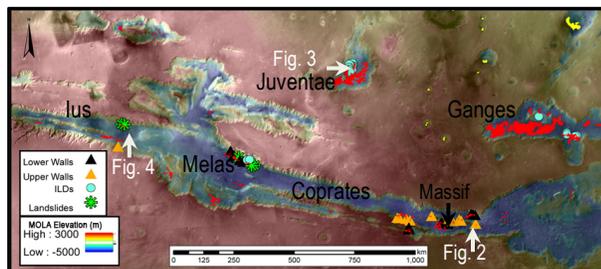


**POTENTIAL SEDIMENT SOURCES AND PATHWAYS IN VALLES MARINERIS DUNE FIELDS: IMPLICATIONS FOR MARTIAN AEOLIAN SYSTEMS.** M. Chojnacki<sup>1</sup>, J. E. Moersch<sup>1</sup>, D. M. Burr<sup>1</sup>, and J. J. Wray<sup>2</sup>, <sup>1</sup>Planetary Geosciences Institute, Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN 37996 ([chojan1@utk.edu](mailto:chojan1@utk.edu)), <sup>2</sup>School of Earth and Atmospheric Sciences, Georgia Institute of Technology, GA, 30332.

**Introduction and Motivation:** As one of the primary Martian sediment sinks, the Valles Marineris (VM) holds nearly a quarter of the global inventory of dune area on Mars [1–2]. The sediment comprising the VM dune fields may have been derived from a variety of potential sediment sources (PSS) (*e.g.*, interior layered deposits (ILDs), spur-and-gully walls, extra-rift sources). Here we expand on the recent documentation that some VM dune fields (Fig. 1) are likely locally-derived from a variety of lithologic sources [3].



**Fig. 1.** Valles Marineris (red) and extra-rift (yellow) dune fields in relation to potential sand sources, as inferred from morphologic, spectral, and/or thermophysical evidence. MOC-WA with MOLA elevation overlaid. Note massif in Coprates is partially obscured by polygons.

**Data:** Geologic context for the dune fields was provided by the CTX [4] and HiRISE [5] cameras. Topography of dune and outcrop surfaces was determined from HRSC camera digital terrain models (DTMs) [6]. Thermal inertia (TI) data from the THEMIS imager [7] were derived to create thermophysical unit maps and infer particle sizes [8]. We used CRISM [9] visible to near-infrared reflectance spectra to determine compositions of dunes and potential source materials.

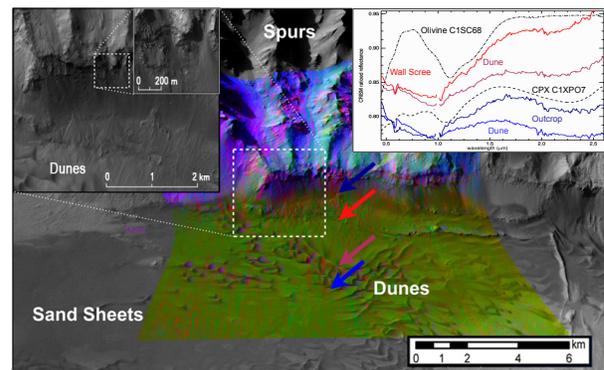
### Results:

**Extra-Rift PSS:** In order to constrain the provenance of VM dune fields, a survey was performed on the ~1000 km region surrounding them. This scale was chosen because it encompasses the estimated maximum transport distance of basaltic sand grain particles due to mechanical weathering [10 and refs. therein]. We identified 22 dune fields, primarily in Lunae Palus and Margaritifer Sinus, 19 of which are small (2–70 km<sup>2</sup>, ~1600 km<sup>2</sup> total). The total area of these dunes is <8% of the dune field area mapped within VM. The majority of these crater-confined dune fields are found with paleo-wind indicators (*i.e.*, slip faces, dark streaks) suggestive of transport away from VM, with a few exceptions northeast of the rift. To date, no dune

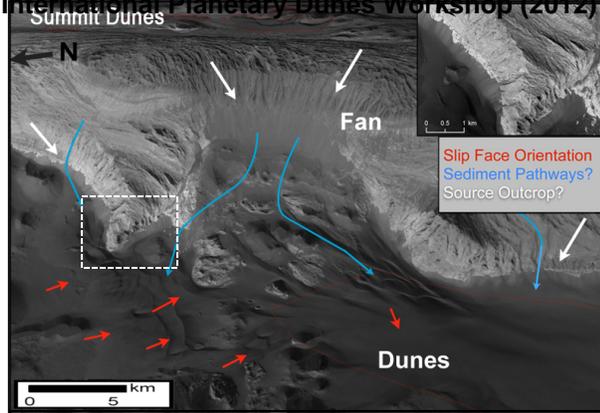
fields have been located within ~200 km of the VM rim (Fig. 1).

**Spur-and-Gully Wall PSS:** Coprates and Melas chasmata (Fig. 1) contain ~12% of the VM dune field areal inventory, with a rich diversity of dune morphologies and topographic relationships. Dunes are often in close proximity to or atop wall material that has been deposited by mass wasting. For example, Fig. 2 shows a ~800-m-tall, steep (30–40°) wall scarp and associated talus above a floor dune field. This lower wall segment is interpreted as massively-layered flood basalts [12]. CRISM spectra of both the dunes and lower-wall scree show evidence for both olivine-bearing basalt and high-calcium pyroxene (HCP). In contrast, other wall spurs in that figure display spectral characteristics that match those of low-calcium pyroxene (LCP) and Fe/Mg-smectite [12], and dune fields west of this location have dominantly olivine-bearing compositions [3]. TI values of the dune surfaces closest to the scarp are ~370 Jm<sup>-2</sup>K<sup>-1</sup>s<sup>-1/2</sup>, consistent with coarse sand, whereas TI monotonically decreases paleo-downwind (as inferred by slip faces orientation).

Falling dunes (a type of topographically constrained duneform) in VM are most commonly located within Coprates Chasma gullies adjacent to dark-toned upper-wall PSS [13]. Most of these coarse-grained (as inferred from TI) dunes occur on a topographically isolated 200-km-long massif (Fig. 1) where extra-rift sources are not likely. CRISM spectra of local falling dunes and adjacent upslope outcrops match each other with variable basaltic spectra, but are distinct from spectra of lower-wall PSS.



**Fig. 2.** A CTX perspective view of Coprates Chasma dune-wall relationships using a HRSC DTM colored with CRISM (FRT 21CB0 where HCPINDEX (red), OLINDEX (green), and LCPINDEX (blue) [11]). (inset) HiRISE (ESP\_025731\_1655) views of select locations along the steep ~30–40°-scree-slopes above dunes. CRISM spectra (inset) of dunes and PSSs. Note that lab spectra (black dashed) are in units of reflectance.

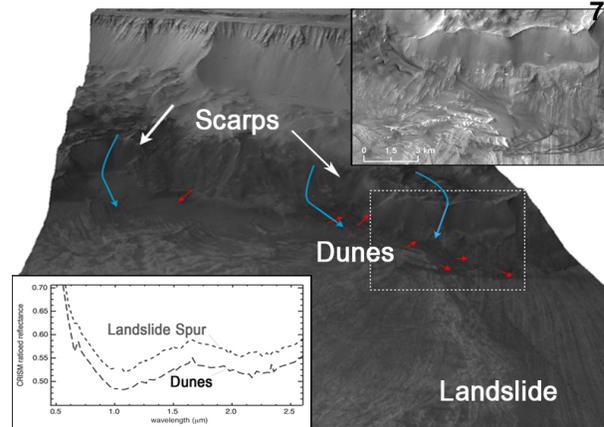


**Fig. 3.** Eastward perspective view of Juventae Chasma ILDs in relation to several dune fields (CTX using a HRSC DTM). CRISM observation show HCP associated with fans, floor dunes, and sand sheets to the south, whereas summit dunes are olivine-bearing [3].

**ILD PSS:** Juventae and Ganges chasmata both host massive ergs and smaller dune fields (~80% of total VM dune field area) in close association with ILDs. These massive layered deposits, although usually associated with hydrated sulfates, are also partially composed of mafic mineralogies [3,11,14]. For example, one topographically-isolated dune field found atop the summit of a Juventae Chasma ILD (Fig. 3) possess a spectra (consistent with olivine) similar to that of a regional mantling unit and was interpreted as evidence for local provenance [3]. Here, as with Ganges Mensa and other VM ILDs, morphologic evidence for mass-wasting of fans can be found [1,15]. Additional mid-toned material is observed on the slope to the west, where barchanoid dunes and sand sheets are located (Fig. 3, inset). Dunes, sand sheets to the south, and the ILD-sourced fans have the same broad absorption features at ~1.1 and ~2.3  $\mu\text{m}$ , consistent with HCP [3].

**Landslide PSS.** Several VM dune fields are superposed on late Amazonian (<1 Ga) landslides [16], primarily located in Ius, Melas, and Hebes chasmata. One example, in Ius Chasma (Fig. 1), shows a small landslide dune field adjacent to eroding landslide scarps (Fig. 4). CRISM multispectral observations of both scarp material and dunes show absorption features indicative of HCP-bearing basalt.

**Interpretations:** A variety of findings indicate local sources provide sediment for the dunes. Spectral pairing between dune and outcrop/talus surfaces are consistent with local derivation of dune sediment from Coprates wall (Fig. 2), Juventae ILD (Fig. 3) and Ius landslide scarp (Fig. 4) materials. In Coprates chasma, we interpret the thermophysical trend below the scarp as evidence for the deflation of finer sand particles leeward of the PSS, although mechanical breakdown may also be a factor. The falling dunes spectra, along with previous morphologic and thermophysical evidence [13], suggest discrete, local (<10 km) sediment pathways from wall gullies down to chasm floors as a source for larger floor dune fields.



**Fig. 4.** CTX perspective view of Ius Chasma landslides and dunes (CTX using a HRSC DTM). CRISM multi-spectral spectra of scarps and dunes, consistent with HCP, are similar. Annotations are the same as Fig. 3.

**Discussion and Summary:** Numerous observations in VM link specific outcrop materials to individual dune fields. However, given the long history of VM, multiple sources, including other dunes and extrarift material, also seem likely. Eastern Coprates Chasma provides robust evidence for local derivation of aeolian sediment from specific stratigraphic levels of local spur-and-gully walls. Mantling units and fan material of ILDs in Juventae Chasma show evidence as sources for separate yet adjacent and spatially large dune populations. These examples of spectrally distinct dune fields in close proximity (~10 km) to one another argue for discrete, relatively unmixed sediment sources, counter to the notion that Martian sands and (by extension) dark soils have been globally homogenized [17]. Future work will continue to test the hypothesis for local provenance of VM dune fields.

We speculate that several mechanisms are responsible for the breakdown of VM PSS geologic units, depending on the location and starting compositions: susceptibility of basalt to thermal stress (*i.e.*, thermal stress fatigue, thermal shock) [18], impact gardening, aeolian erosion, and ancient weakening of bedrock due to a aqueous alteration/digenesis [12], all compounded by gravity driven processes. The high relief and exposure of the strata of VM may be driving factors in sourcing sediment for widespread aeolian bedforms across the rift.

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