AEOLIAN SEDIMENT SOURCES AND TRANSPORT IN GANGES CHASMA, MARS: MORPHOLOGY AND ATMOSPHERIC MODELING. L. K. Fenton[1] , T. I. Michaels[2], and R. A. Beyer[1,3], [1]Carl Sagan Center at the SETI Institute, 189 Bernardo Ave, Mountain View, CA, 94043, USA, (lfenton@carlsagancenter.org), [2]Southwest Research Institute, 1050 Walnut St., Suite 300, Boulder, CO, 80302, USA [3]NASA Ames Research Center, Moffett Field, CA 94035, USA.

Introduction: Ganges Chasma (307-320º E, 5.8-10.7º S) is a large, nearly isolated canyon at the eastern end of the Valles Marineris system on Mars (see Fig. 1). It ranges in width between 50 and 170 km, and it extends ~700 km from its western margin to the east where it opens into Eos Chasma. The chasma contains several mounds of layered materials that, like many others in the Valles Marineris system, contain sulfate and hematite; such minerals are thought to have formed under drastically different climatic conditions than currently exist on Mars [1,2]. These mounds are heavily eroded and were likely once much more extensive, suggesting that large volumes of sediment have been removed by the wind [3].

Extensive portions of the chasma are covered in sand sheets, and several dune fields are scattered across the canyon floor (see Fig. 1). It is likely that the layered mounds provide a source of material for, and/or were eroded by, this volume of sand. An understanding of bedform morphology and the local wind regime can be used to reconstruct sediment transport pathways, thus determining the role that sand has played in forming and eroding the sulfate- and hematite-bearing layers. We present first results from bedform mapping and atmospheric modeling that suggest 1) sand sources are widespread throughout Ganges Chasma and 2) saltation threshold friction velocities may be lower than expected.

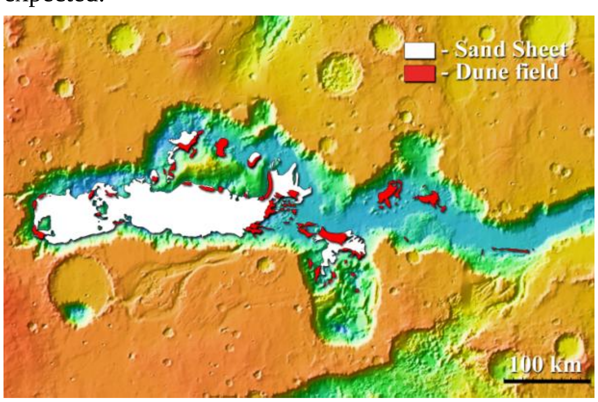

Figure 1. Ganges Chasma on MOLA shaded relief, showing the locations of dune fields and sand sheets.

Method: Morphology and Modeling

*Morphology***.** Using JMARS [4], projected CTX images across Ganges Chasma were searched for aeolian features. Sand sheets and dune fields were outlined. Unidirectional features (including wind streaks, isolated barchan dunes, yardangs, and scours in the lee of topographic obstacles), which may be regarded as local "wind vanes", were identified. Finally, the crestlines of large dune fields were mapped.

Atmospheric modeling with the Mars Regional Atmospheric Modeling System (MRAMS). We ran twelve simulations at Ganges Chasma using MRAMS, a non-hydrostatic, finite-difference, limited domain mesoscale model [5]. Each simulation ran for three martian days, and they collectively span the martian year (they are spaced in time by 30º L_s).

The atmospheric circulations within Ganges Chasma are complex and three-dimensional due (in large part) to the canyon's extreme topographic contrasts. In order to simulate such phenomena at the relatively high spatial resolutions used in this work, a large number of grid points are required and relatively small (of order one second) dynamical timesteps are needed to maintain numerical stability.

These requirements are computationally impractical if a traditional constant timestep is employed. Instead, to make the simulations presented here feasible, a resilient variable timestep computation was used, which results in a significantly longer (on average) model timestep. This algorithm uses the relatively standard practice of adjusting the timestep on each grid based on current model diagnostics (themselves functions of grid-spacing, wind velocity, etc.). Nesting down from a nearly global domain, the final domain consists of 236 x 92 grid points spaced by 3.9 km horizontally. Output parameters (e.g., friction velocity, air pressure) at each grid point were saved 72 times per martian day.

Analysis: Transport Pathways

Morphology. The sand sheets span 15,600 km^2, and are concentrated in the western part of the chasma. Several dozen dune fields collectively span nearly 2400 km^2, the largest of which covers 305 km^2. Burial of local topography suggests the sand sheet may be as thick as 200 m in some places; assuming a mean thickness of 50 m, a quick estimate of the total sand volume is 850 km^3.

Unidirectional features are abundant in the chasma. With few exceptions, each of these wind markers indicates dominant transport towards the west, with minor flows from reentrants directed towards the center of the main canyon. It is likely the large sand sheets (see

Fig. 1) accumulated over time from such along-canyon flows.

In contrast, the morphology of most of the dune fields reflects more than one sand-transporting wind. Sand entering these areas would be trapped by convergent winds that keep sand from being blown farther downwind.

Modeling. Using MRAMS output, we estimated the potential sediment transport in Ganges Chasma throughout the martian year. The potential sediment flux Q was calculated for each grid point and each time step using the empirical relation from [6]:

$$Q = 0.261\frac{\rho u_*^3}{g}\left(1-\frac{u_{*t}}{u*}\right)\left(1+\frac{u_{*t}}{u_*}\right)^2 \qquad \text{kg m}^{-1}\ \text{s}^{-1}$$

in which ρ is the air density, g is gravitational acceleration, u_* is friction velocity, and u_{*t} is the threshold friction velocity for sand saltation. Threshold friction velocities were calculated using [7], assuming sand grains have a density of 3000 kg m^{-3} (i.e., basalt) and a diameter of 100 μm.

MRAMS predicts that two major air flows blow strongly enough to entrain sediment on the floor of Ganges Chasma: (southern) spring and summertime flows down the northern canyon walls, and gentler easterly flows that occur year-round. Although the easterly flows are consistent with observed unidirectional "wind vanes", they are far outstripped by the seasonal northerly winds. Possible explanations for this discrepancy are 1) the model is incorrectly representing the wind regime (e.g., by omission of stochastic events such as dust storms), 2) the aeolian features represent a wind wind regime that no longer exists, and 3) threshold friction velocities are much lower than those estimated from [7].

Assuming threshold friction velocities are one tenth those estimated from [7], the easterly flows in the canyon nearly balance the strong northerly spring and summer flows, resembling the transport pattern indicated by unidirectional wind markers (see Fig. 2). This result lends some support to [8], who predicts that impact saltation thresholds are about an order of magnitude lower than those determined from previous studies (provided saltation is initiated with a stronger wind).

Conclusions: Several lines of evidence suggest that a large quantity of sand has moved westward from sources distributed across Ganges Chasma, including: 1) Large sand sheets that have accumulated in the west, 2) dune fields that have formed in areas where winds converge, trapping sand that would otherwise be transported downwind, 3) unidirectional wind markers that consistently indicate westward transport, and 4) yardangs in layered materials that show the former passage of large quantities of sand.

Finally, atmospheric modeling reproduces the observed wind regime best for saltation threshold friction velocities one tenth those of traditional values.

References: [1] Bibring, J.-P. et al. (2006) *Science, 312*, 400, doi:10.1126/science.1122659. [2] ChojnackI, M. and Hynek, B. M. (2008) *JGR, 113*, E12005, doi:10.1029/2007JE003070. [3] Beyer, R. A. (2006) *LPS XXXVII*, Abstract #1914. [4] Gorelick, N. S. et al. (2003) *LPS XXXIV*, Abstract. #2057. [5] Rafkin, S. C. R. et al. (2001) *Icarus, 151*, 228-256. [6] White, B. R. (1979) *JGR, 84*(B9), 4643-4651. [7] Greeley, R. and Iversen, J. D. (1985) *Wind as a Geological Process*, p. 76-82. [8] Kok, J. F. (2010) *GRL, 37*, L12202, doi:10.1029/2010GL043646.

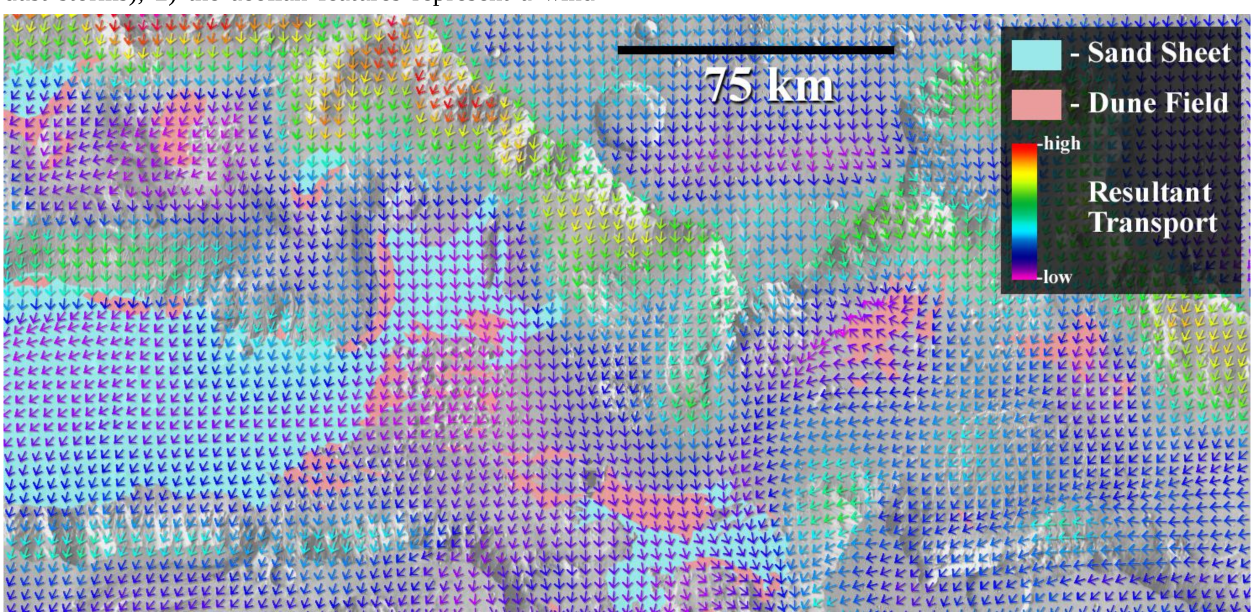

Figure 2. Central Ganges Chasma, with resultant transport vectors calculated using a threshold friction velocity (u_{*t}) one tenth that estimated from [7]. Easterly along-canyon flows and northerly flows down canyon walls compete for prominence on the floor of Ganges Chasma.