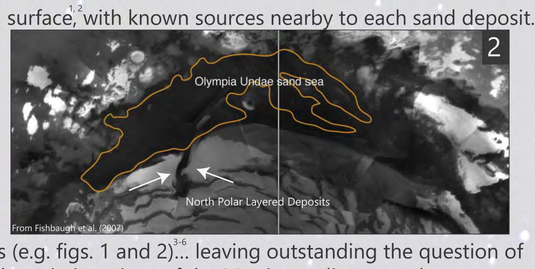
INVESTIGATING THE SOURCES AND ORIGINS OF DARK SAND IN AEOLIS DORSA, MARS: EVIDENCE FOR LOCAL DARK SAND PRODUCTION

BOYD, A. S.[1], and BURR, D. M.[1]

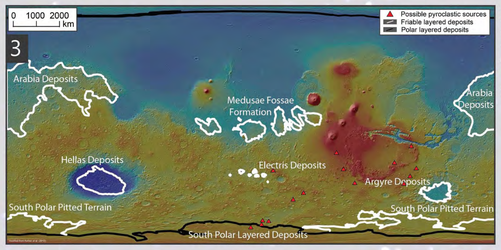
[1]Department of Earth and Planetary Sciences, University of Tennessee, Knoxville. (aboyd21@utk.edu)

BACKGROUND

Dark sand is found at all latitudes on the Martian surface,[1,2] with known sources nearby to each sand deposit...



... sources which—so far—are sedimentary units (e.g. figs. 1 and 2)[3-6]... leaving outstanding the question of primary **igneous** origin(s) of dark sand, a missing piece of the Martian sediment cycle.

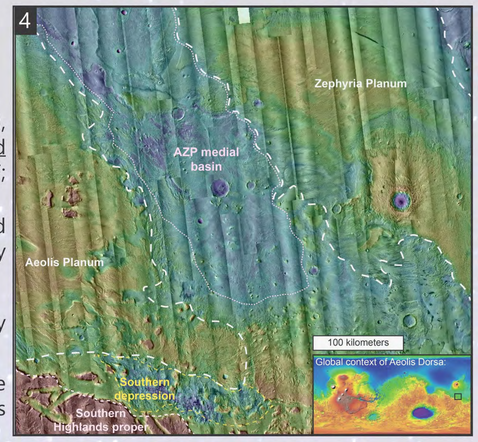


Scientists hypothesize that friable layered deposits[7] (fig. 3) may be sources of sand. Some of these are **hypothesized volcaniclastic deposits**,[e.g. 8] which would provide an igneous origin.

... however, we have yet to infer or observe sand generation from any such deposit.

This research is a case study in **Aeolis Dorsa, Mars** (fig. 4), where dark sand overlies bedrock consisting of a hypothesized volcaniclastic unit, the **Medusae Fossae Formation** (MFF; fig. 5).[9-10]

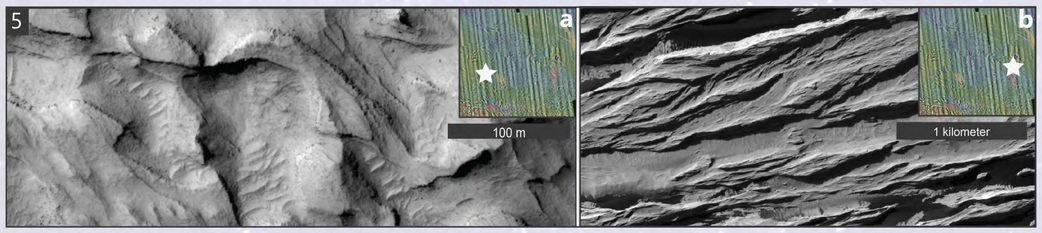
Here, we used sand distribution, paleo-wind directions, and high-resolution images of bedrock exposures to identify likely sand sources.



MFF origins remain unresolved but an increasingly large body of data suggests that is an ignimbrite (pyroclastic flow).[e.g. 11, 12]

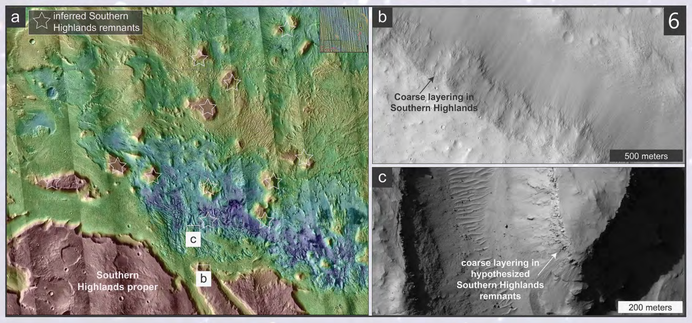
The MFF is characterized by variable layering (fig. 5a), light tone (to which dust contributes), and extensive yardang fields (wind-scoured hills; fig. 5b)

In Aeolis Dorsa, the MFF is the unit comprising Aeolis and Zephyria Plana (fig. 4)



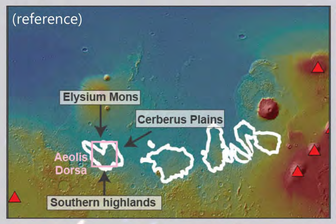
The southern highlands are visible at the southwest corner of Aeolis Dorsa (fig. 6a)...

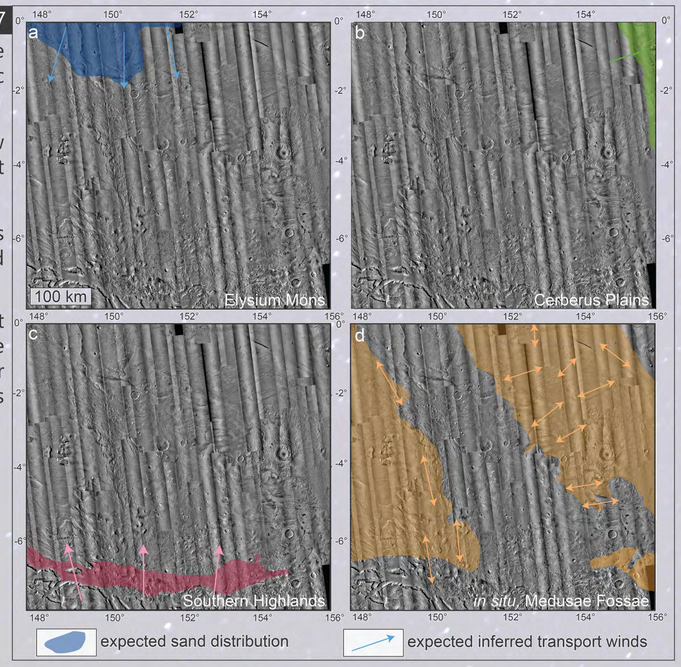
...but morphological similarity between bedrock blocks in the southern depression (outlined in Fig. 4) and the southern highlands suggest that the blocks in the southern depression (starred in 6a) may be remnant southern highlands materials.



POTENTIAL SAND SOURCES

1. Elysium Mons: Erosion of edifice material, or transport of explosive volcanic material, may serve as sand source for AD
2. Cerberus Plains: extensive lava flow deposits may be eroded to loose sediment that is transported to Aeolis Dorsa[13]
3. Southern highlands: Dark sand occurs on southern highlands south of AD, and may be transported to southern AD[14-16]
4. *In situ* erosion of AD bedrock: Posits that sand is sourced from erosion of the Medusae Fossae Formation (MFF) and/or inferred remnant Southern Highlands material





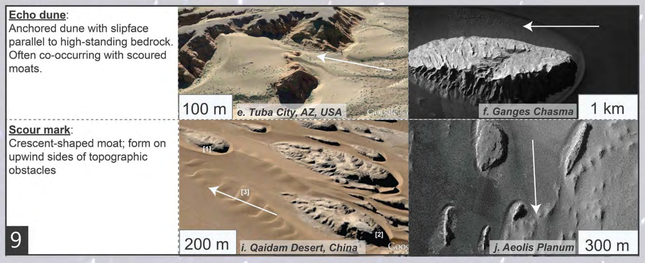
METHODOLOGY

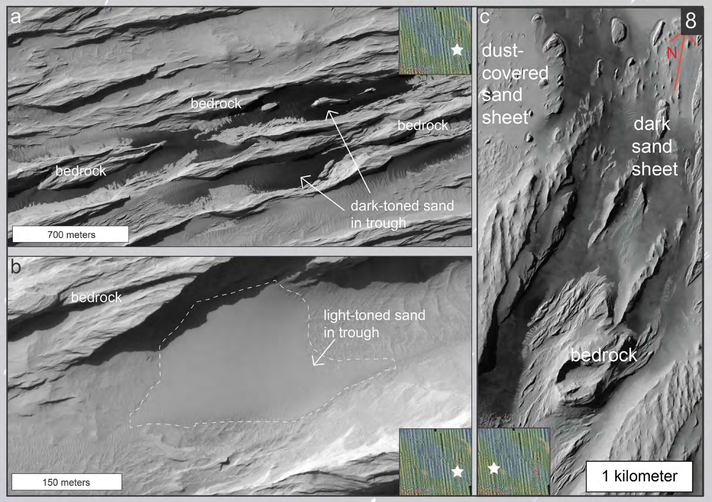
Data collected:

1) Sand distribution around topography as clues for source region (fig. 8)
   - Map sand deposits in study area to identify potential transport paths and transport obstacles

2) Scour mark orientations[17] and inferred wind directions to identify paleo-wind directions (figs. 8 and 9)

3) Bedrock erosion and talus slopes (where available; limited data) to identify any *in situ* sediment generation



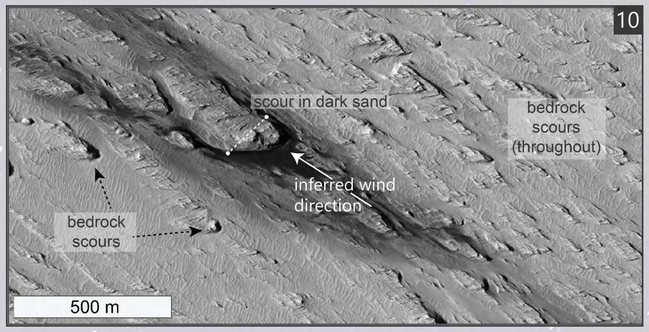


Datasets and conditions:

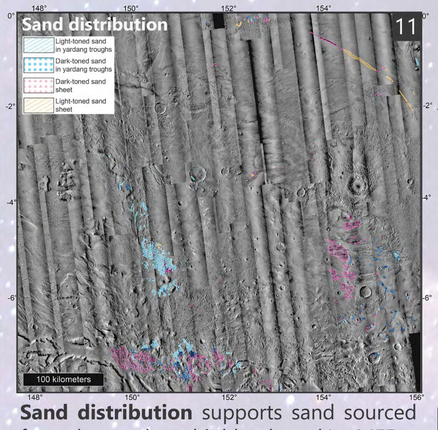
Basemap: moscaic of 6 m/px visible-wavelength images (CTX imagery)[18]
- supplemented with 0.25 m/px images (HiRISE imagery)[19]-- a dataset that only covers portion of the study area

Features mapped as: polygons (sand), lines (scour orientations), and points (slope erosion-- identification limited to HiRISE coverage)

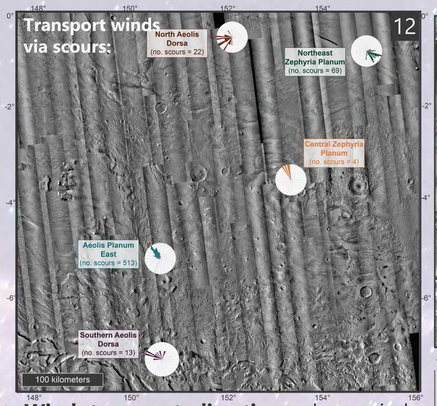
Transport wind analysis: Hierarchical clustering, SPSS Statistics 25



RESULTS

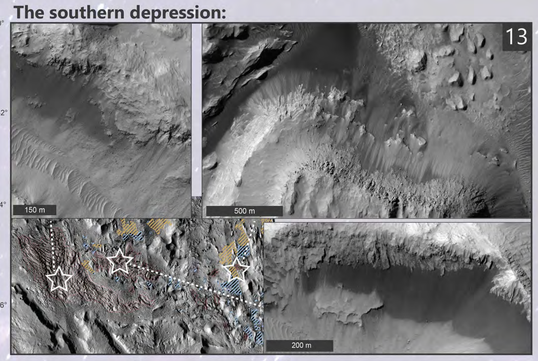


Sand distribution supports sand sourced from the southern highlands and/or MFF...



Wind transport directions show winds deflected around topography...

The southern depression:

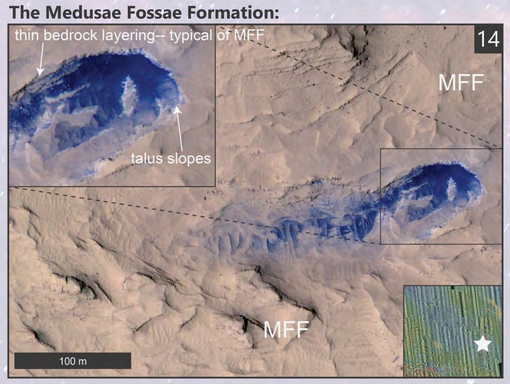


...and **bedrock erosional patterns** show apparent sediment generation from bedrock:

- 100+ talus slopes* in the southern depression (fig. 13)
- 20+ alcoves* in the MFF (figs. 14 and 15)

**note: identification of talus slopes limited to HiRISE coverage*

The Medusae Fossae Formation:



IMPLICATIONS

Sand sources supported:

Southern highlands: sand in the southern depression likely sourced mainly from Southern Highlands remnant materials

Medusae Fossae Formation: sand distribution indirectly supports MFF, and alcoves (figs. 14 and 15) suggest that sand production from MFF can, and may be, occurring
- similar phenomenon observed on Earth (e.g., the Campo Piedra Pomez (CPP) ignimbrite of Argentina)[20]
- volume of sediment in alcoves is small relative to total volume of sand mapped in AD, so these erosional alcoves do not explain the origin of all dark sand in AD.

Apparent sediment generation in MFF: 'proof-of-concept' that friable layered deposits *can* produce sand

REFERENCES

References: [1] Hayward R. K. et al. (2007) JGR, 112, E11007. [2] Hayward R. K. et al. (2014) Icarus, 230, 38-46. [3] Tirsch D. et al. (2011) JGR, 116, E03002. [4] Langevin Y. et al. (2005) Sci, 307, 1584-6. [5] Fishbaugh K. E. et al. (2007) JGR, 112, E07002. [6] Chojnacki M. et al. (2014) Icarus, 232, 187-219. [7] Kerber L. et al. (2012) Icarus, 219, 358-381. [8] Edgett K. S. and Lancaster N. (1993) J. Arid Env., 25, 271-297.

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