#1463

CONSTRAINING SOURCES OF SAND IN THE AEOLIS DORSA REGION, MARS, VIA SAND DUNE MORPHOLOGIES AND SAND DISTRIBUTIONS

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Goals of this study

Addressing the questions of the *geographic sources* and *geologic origins of Martian sand* by identifying likely sources and/or origin(s) of dark and dust-covered sand deposits in Aeolis Dorsa, Mars, at least one of which is adjacent bedrock.

Background

- Sand occurs at all latitudes on Mars [1-3], prompting question of its sources—from where it was transported—and, more fundamentally, its genetic origins
- Most Martian sand sources remain unresolved [exceptions where sources are adjacent to sand, see 4-6]
- One hypothesized origin: weathering of volcaniclastic deposits; such weathering occurs on Earth [7] and is posited to occur also on Mars (but has yet to be observed)
- Aeolis Dorsa (AD) region consists of two twin plateaus, Aeolis and Zephyria plana, separated by a wide basin (the AZP medial basin); Fig. 1
- Bedrock underlying sand deposits includes:
  1) Medusae Fossae Formation (MFF), comprising Aeolis and Zephryia plana;
  2) a blocky massif unit, primarily restricted to the southern depression (see Fig. 1)
- The MFF is hypothesized to be volcaniclastic in origin [8, 9]; the nature of the massif-forming unit is unknown, but may consist of southern highlands material
- Additional potential external sand sources surround AD, including Cerberus plains lavas, Elysium Mons edifice materials, or southern highlands (Fig. 1, regional context)
- If the MFF, Cerberus lavas, or Elysium Mons volcanics are sourcing sand in the AD region, they would provide igneous origins for this sand.

Hypotheses

Regional geology supports four working hypotheses for AD sand source(s) (Fig. 1, regional context):

1. *In situ* bedrock weathering:
- Weathering of dark layers in MFF (e.g., Aeolis and Zephyria planum material) to dark sand
- Weathering of dark layers in massifs to sand

1a. Observations that would support this hypothesis: (a) sand concentrated in bedrock troughs; or (b) inferred locally-controlled wind directions rather than favoring external source(s)

2. Elysium Mons:
- Sand-sized volcaniclastic sediments ejected from Elysium Mons, or effusive lava flow materials from edifice, could be transported to AD region

2a. Observations that would support this hypothesis: (a) sand concentrated in northern part of study region, esp. in AZP medial basin (ref., Fig. 1); (b) aeolian features (e.g., dunes, scour marks, wind streaks; see examples in Figs. a-c) indicative of southward winds, i.e., scours on northerly sides of obstacles

3. Cerberus plains lavas:
- Impact cratering and/or [potentially ongoing; 10] seismic activity could produce sand-sized sediment from extensive CP lava flows [11]

3a. Observations that would support this hypothesis: (a) high sand concentrations on the western side of Zephyria Planum; (b) aeolian features indicative of westward winds, e.g., scours on E side of obstacles

4. Southern highlands:
- Dark sand occurs on the southern highlands south of the AD region [1, 12]
- Sand may be transported down-elevation, across HLB, into lower-elevation AD region

4a. Observations that would support this hypothesis: (a) high concentrations of sand in southern part of study area; (b) aeolian features indicative of northward winds, e.g., wind streaks extending to N of obstacles

Data and methods

- *Basemap*: Context Camera [CTX; 13] image mosaic, resolution = 6 m/pixel (Fig. 1)
- Additional imagery used to identify *in situ* bedrock erosion: High Resolution Imaging Science Experiment [HiRISE; 14]
- Sand deposits mapped in ArcMap as polygons; additional data for each deposit recorded in attribute table (Table 1)
- Directions for scour marks and wind streak orientations: “N” = 315°-045°, “E” = 045°-135°, “S” = 135°-225°, “W” = 225°-315°, “NW” = 225-045°, “NE” = 315-135°, “N 180°” = 270-045°, etc.

Feature type	Length (m)	Area (m)	Scour marks:	N	E	S	W	NW	NE	N 180°	Transv. dunes:	E-W	N-S	Wind-streaks:	Extending to S	Follow ing troughs	Bedrock erosion
dark sand in trough	6.97E+03	2.49E+06									1						
dark sand	2.98E+04	1.20E+07	11	1						1				1	1		1
dark sand	1.40E+04	9.29E+06									1		1	1	1		1
dark sand	4.99E+04	5.18E+07	1				1	1		1				1	1		

Table 1. Simplified attribute table used for annotating mapped sand deposit polygons (”transv. dunes” = transverse dunes).

Two approaches to data analysis:

1. Sand deposit clustering analysis:
- Standard ArcMap clustering analyses:
  (1) Average Nearest Neighbor
  (2) Ripley’s K function
  (3) quadrat overlay

Reason for use: represents clustering of discrete deposits

2. Geospatial sand distribution:
- Techniques using sand deposits in lattice (raster) form:
  (1) Global and Local Moran’s I
  (2) Getis-Ord’s G statistic

Reason for use: represents entire area of sand coverage

References & acknowledgments

References: [1] Hayward R. K. et al. (2007) *JGR, 112*, E11007. [2] Hayward R. K. et al. (2009) *JGR, 114,* E11012. [3] Hayward R. K. et al. (2014) *Icarus, 230*, 38-46. [4] Langevin Y. et al. (2005) *Science, 307*, 1584-6. [5] Mangold N. et al. (2007) *JGR, 112,* E08S04. [6] Chojnacki M. et al. (2014) *Icarus, 232,* 187-219. [7] Edgett K. S. and Lancaster N. (1993) *J. Arid Env., 25,* 271-297. [8] Bradley B. A. et al. (2002) *JGR, 107*, E8. [9] Mandt K. E. et al. (2008) *JGR, 113,* E12011. [10] Roberts G. P. et al. (2012) *JGR, 117,* E02009. [11] Keszthelyi L. et al. (2004) *G3, 5*. [12] Tirsch D. et al. (2011) *JGR, 116,* E03002. [13] Malin M. C. and Edgett K. S. (2001) *JGR, 106,* 23429-570. [14] McEwen A. S. et al. (2007) *JGR, 112,* E05S02.

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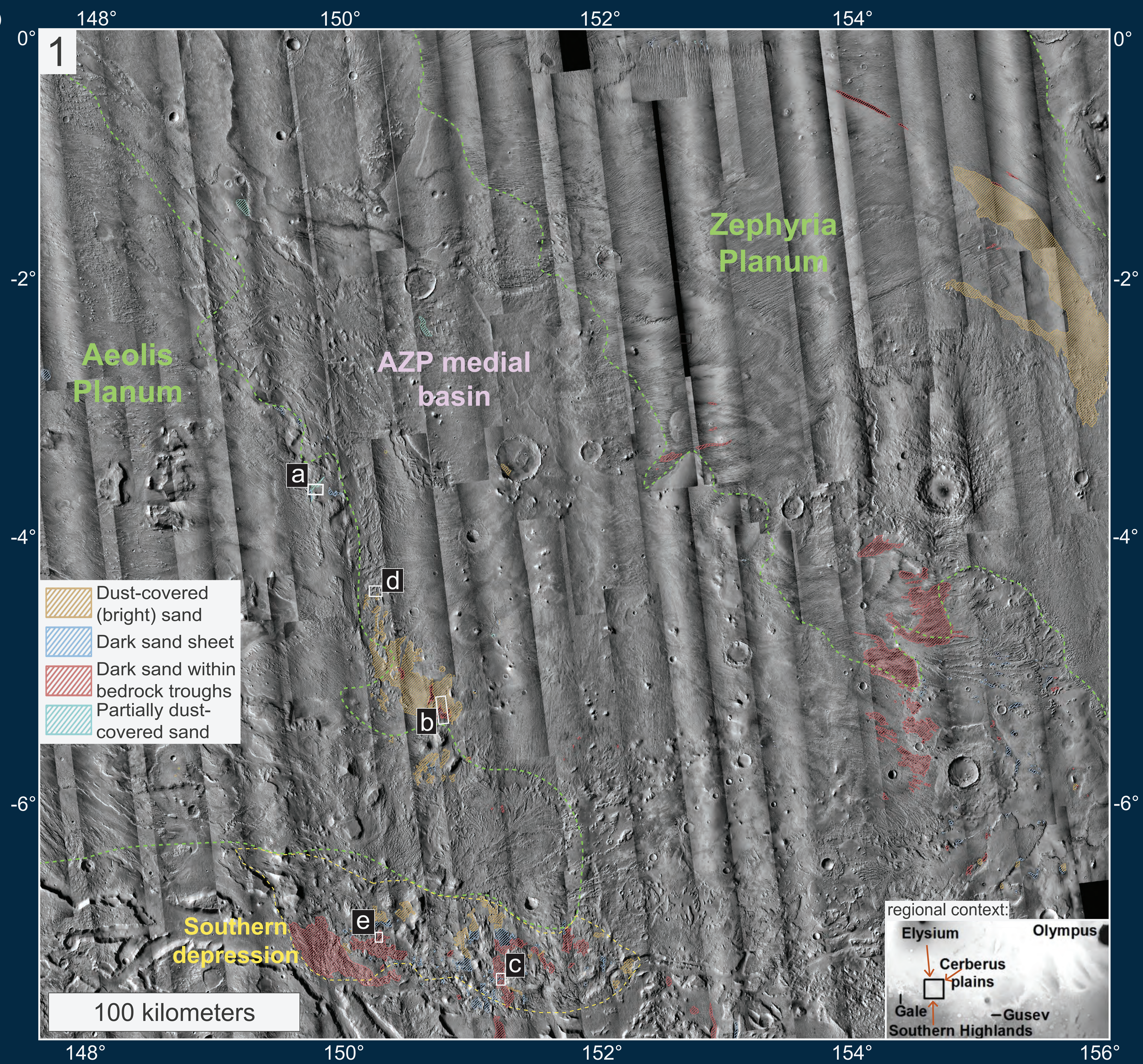

Figure 1. Map of the Aeolis Dorsa region, Mars. Sand deposit preliminary mapping outlined according to legend. Inset shows regional context, along with arrows indicating wind directions from possible sand source regions. Southern depression (yellow) lies ~500 m below surrounding terrain.

Preliminary findings

Geospatial sand distribution (Fig. 1)
- Sand deposits concentrated in southern depression
- Sand deposits occur on, or on the periphery of, Aeolis and Zephyria plana
- Paucity of sand in the AZP medial basin

Aeolian feature orientations (Figs. a-c)
- Transverse dunes are oriented normal to adjacent elongate bedrock outcrops (Fig. a)
- Scour orientations vary locally, but regional dominance of scours on northerly sides of obstacles (Figs. b, b_{ii})
- Wind streaks have only been observed within troughs, but they both follow trough orientations and extend southward from obstacles (Fig. c)

Bedrock erosion (Figs. d-e)
- Bedrock erosion on yardangs in Aeolis Planum (Fig. d, d_{ii})
- Significant bedrock erosion, and deposition in adjacent troughs, in the southern depression (Fig. e)

Possible explanations for these findings:

(1) Wind direction is topographically controlled (supported by aeolian feature orientations), or

(2) dominant regional winds from the north (supported by aeolian feature orientations)

(3) At least one source of sediment is erosion of bedrock (evidenced by observed erosion)

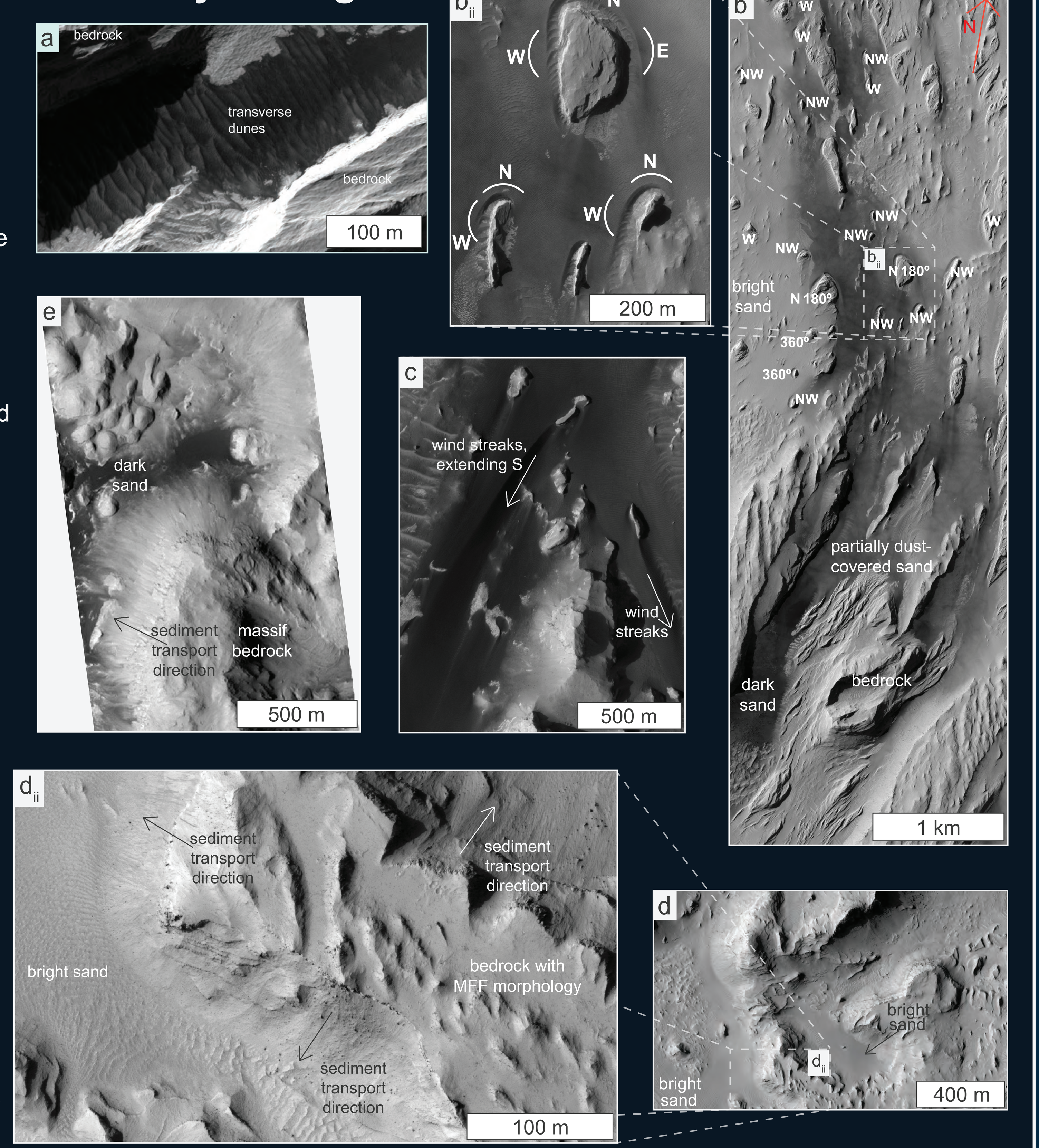

Figure 1, cont. North is up on all images unless otherwise noted. a) Transverse dunes in dark sand, oriented normal to a bedrock trough on Aeolis Planum. b) Variety of sand deposit classes (noted via text) and numerous scours on Aeolis Planum. Lettering (e.g., “NW”) next to scours indicates recorded orientations; inset shows extent of scour wrapping that constitutes various directions. c) Wind streaks in dark sand, following bedrock trough in the southern depression. d) Bright sand deposit adjacent to eroding layers of (likely MFF) bedrock on Aeolis Planum. Inset shows detail of erosion. e) Erosion of dark layers in massif bedrock, with adjacent dark sand deposit. Image credits: NASA/JPL/UA.