PLANETARY DUNE FIELDS: EXAMPLES OF PERFORMANCE UNDER PRESSURE. J. R. Zimbelman, CEPS/NASM MRC 315, Smithsonian Institution, Washington, DC 20013-7012; zimbelmanj@si.edu.

Introduction: Aeolian studies focus on deposits and processes observed at the interface between a wind-driven atmosphere and a surface of particulate materials, possibly including large blocks or bedrock. Robotic exploration of the solar system has expanded the range of environments in which aeolian deposits have been documented. This report focuses on dune fields observed on several planetary surfaces, following a sequence from lowest to highest atmospheric pressure (Table 1).

Table 1: Properties of planetary environments [from 1]

	Venus	**Earth**	**Mars**	**Titan**
g (m/s^2)	8.88	9.81	3.73	1.36
p (mb)	90000	1013	7	1600
Comp. (%)	CO_2, N_2	N_2, O_2	CO_2, N_2	N_2, CH_4
	(96, 3.5)	(77, 21)	(95, 2.7)	(90, 10)
T_{surf} (°C)	480	22	-23	-200

Mars: Dune fields were first observed on Mars in Mariner 9 images [2]; subsequent spacecraft provided information on the diversity and distribution of dunes across the planet [e.g. 3-5]. Other than the north circumpolar dune field [6], most dune fields on Mars occur on the floors of large impact craters (Fig. 1) [3, 4].

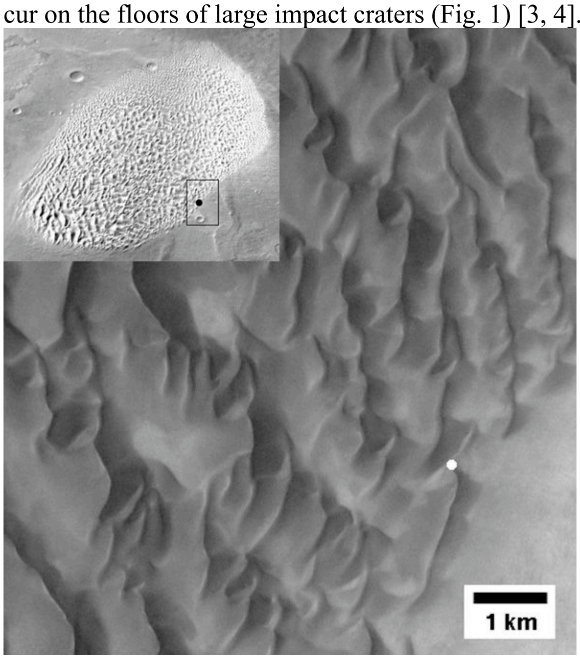

Figure 1. Dune field in Proctor crater, Mars, 47.8°S, 30.7°E. THEMIS V16837003, 17 m/p (ASU). Inset: THEMIS mosaic [7]. Dots show location of Figure 2.

For example, the Proctor dune field has been the subject of detailed mapping and monitoring [8], now supplemented by coverage from HiRISE (Fig. 2). Martian dunes display a variety of forms, from barchans to transverse ridges [3], but there is a lack of longitudinal dunes [9]. MER observations indicate both basaltic sand and dust aggregates on aeolian bedforms [5, 10].

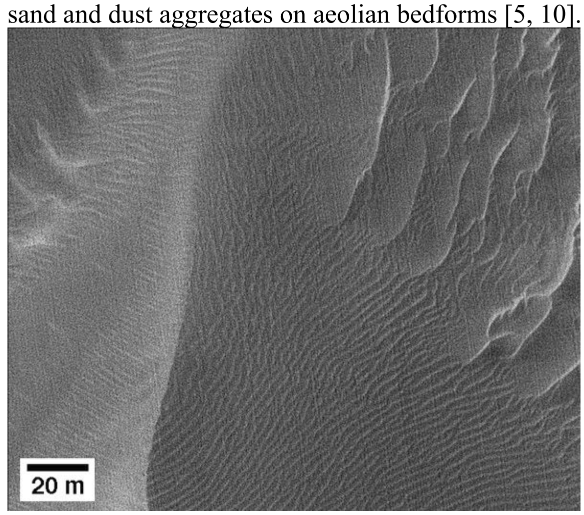

Figure 2. HiRISE view of Proctor dunes and ripples (see Fig. 1). PSP_002455_1320, 25 cm/p (U of A).

Earth: Spacecraft sensors documented dune fields across the planet [e.g., 11] at scales comparable to recent data from Mars (compare Figs. 1 and 3). The vast

Figure 3. Kelso dune field, California, 34.901°N, 115.727°W. ASTER data, acquired on 10/17/00, 15 m/p [12].

array of dune forms found on Earth [e.g., 1, 11, 13] have not yet been observed on other planets, but the physics of particulate movement by the wind established on Earth [14] is readily applicable to other planetary environments [1].

Titan: The RADAR experiment on the Cassini spacecraft is mapping swaths across haze-shrouded Titan; primarily in equatorial areas, large fields of longitudinal dunes are common (Fig. 4, [15]). Radar data

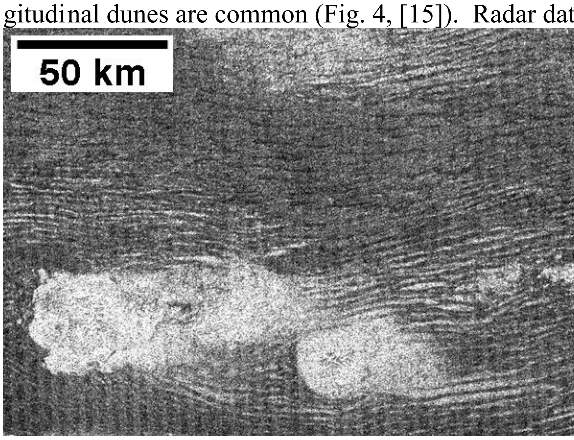

Figure 4. Longitudinal dune field on Titan, 8°N, 44°W. Cassini SAR, ~500 m/p, PIA087380 [15].

show the dunes on Titan have a spacing of 1 to 3 km, lengths of many tens of km, and heights of 100 to 150 m, likely comprised of sand-sized particles consisting of hydrocarbon materials or methane ice coated by hydrocarbons [16]. Thus far, dunes other than those in the longitudinal dune fields are uncommon.

Venus: The Magellan mission used a Synthetic Aperture Radar (SAR) experiment to map >98% of Venus, revealing the presence of >6000 aeolian features across the planet [17]. While wind streaks represent the most common aeolian feature on Venus [18], two prominent fields of dunes were identified: the Aglaonice dune field (Menat Undae, 25°S, 340°E) covering ~1300 km^2, and the Fortuna-Meshkenet dune field (Al-Uzza Undae, 67°N, 91°E) covering ~17,100 km^2 [17-19] (Fig. 5). The dunes in the Fortuna-Meshkenet field consist of arcuate ridges 0.5 to ~10 km in length, oriented transverse to wind streaks in the immediate area, with widths of 0.2 to 0.5 km and an average spacing of 0.5 km (Fig. 5) [17]. The dunes appear to have slopes <25° based on SAR images obtained during separate mapping cycles with different look orientation; several other regions in the southern hemisphere of the planet may have 'microdunes' whose presence is inferred because they are spaced properly for Bragg scattering and/or they have near-normal dune faces that produce subpixel reflections [20].

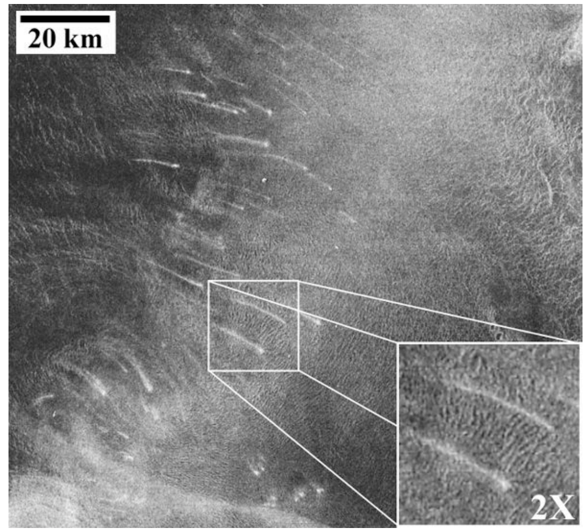

Figure 5. Fortuna-Meshkenet dune field on Venus, 67°N, 91°E. Magellan SAR, ~100 m/p, from NASA F-Map 66N084.

Discussion: The vast differences in atmospheric pressure represented by the above features do not seem to have a strong effect on sand-sized particles that have collected into dunes and dune fields. This is likely a result of the fact that while the threshold friction speed ranges widely for the environments from Mars to Venus, the particle size most easily moved by the wind ranges only from 75 to 180 microns within this broad pressure regime [1].

References: [1] Greeley R. and Iversen J. D. (1985) *Wind as a geological process on Earth, Mars, Venus, and Titan*, Cambridge U Pr. [2] McCauley J. F. (1973) *JGR, 78*, 4123-4137. [3] Greeley R. et al. (1992) *Mars* (H. H. Kieffer et al. Eds.), U of Ariz. Pr., 730-766. [4] Fenton L. K. et al. (2007) LPS XXXVIII, Abs. #1486. [5] Greeley R. et al. (2006) *JGR*, *111*, E02S09, doi: 10.1029/2005JE002491. [6] Tsoar H. R. et al. (1979) *JGR, 84*, 8167-8180. [7] marsoweb.nas.nasa.gov/HiRISE. [8] Fenton L. K. (2005) *JGR*, 110, E06005, doi: 10.1029/2004JE002309. [9] Malin M. C. and Edgett K. S. (2001) *JGR,* 106, E10, 23,429-23,570. [10] Sullivan R. et al. (2008) LPS XXIX, Abs. 2092. [11] Breed C. S. et al. (1979) *USGS Prof. Paper 1052*, 305-397. [12] ivis.eps.pitt.edu/data/Mojave. [13] Lancaster N. (1995) *Geomorphology of Desert Dunes*, Routeledge, London. [14] Bagnold R. (1941) *Physics of Wind-blown Sand and Desert Dunes*, Methuen, London. [15] photojournal.jpl.nasa.gov. [16] Lorentz R. D. et al. (2006) *Science, 312*, 724-727, doi: 10.1126/science.1123257. [17] Greeley R. et al. (1997) *Venus II* (S. W. Bougher et al., Eds.), U of Ariz. Pr., 547-589. [18] Greeley R. et al. (1995) *Icarus, 115*, 399-420. [19] Greeley R. et al. (1992) *JGR, 97*, 13319-13345. [20] Weitz C. M. et al. (1994) *Icarus, 112*, 282-295.