MORPHOLOGIES, MORPHOMETRIES AND SAR BRIGHTNESSES OF YARDANGS AND DUNES ON EARTH AND TITAN. J. Radebaugh[1] R.D. Lorenz[2], P. Paillou[3] and D. Northrup[1]. [1]Brigham Young University, S-389 ESC, Provo, UT USA 84602, janirad@byu.edu, [2]Johns Hopkins Applied Physics Laboratory, Laurel, MD, USA, [3]Universite de Bordeaux, Floriac, France.

Introduction: Wind-erosional landscapes on planetary surfaces are often dominated by yardangs, which are created by the stripping of surface materials by winds. They are long, narrow, parallel ridges having steep slopes, streamlined shapes and blunt upwind margins [1,2]. There are many similarities in their basic morphology to linear dunes, which are also long, narrow and generally parallel [3]. Yet, there is something about their shape that makes it known they are yardangs and not dunes. We seek to describe general differences between yardangs and dunes in terms of basic morphology, and then to quantify these differences through analyses of length, width, spacing, discontinuousness of form and sinuosity, the latter two factors being perhaps most discriminating. In addition, analysis of radar response can help reveal material differences.

If we can define the similarities and differences between dunes and yardangs on Earth, then we can apply these factors to possible yardangs on other planets [4,5]. This will be especially useful where resolutions are poor, such as on Titan [6] and Venus [7]. The study of and discrimination between dunes and yardangs can reveal wind direction and strength, the presence and condition of sediments, the nature and erodability of the substrate and regional climate [1].

Yardangs of China and Iran and Dunes of Egypt: Yardangs are found in many deserts on Earth. Yardangs in Dunhuang, western China, at 40°30' N, 93°06' E (Fig. 1) have an average length in this portion of the field of ~2.5 km. They are generally straight, are highly discontinuous, and have large variability in width. They range in width from ~30-165 m, with an average of ~60 m, for a roughly average length:width relationship of 40:1, slightly higher than determined for other yardang fields on Earth [8,9].

The Lut Desert of Iran is home to one of the largest yardang fields on Earth, at 30°24' N, 58°22' E. Yardang spacing is very dense and interyardang width small. The yardangs are discontinuous and the forms feather into each other in a mosaic pattern (Fig. 2). Yardangs here can reach 120 km, and while width and spacing are difficult to measure (this is underway), a very rough average width in the center of ~600 m yields a rough length:width of 200:1.

Linear dunes in the Egyptian Great Sand Sea, by comparison, are also long, narrow and straight. These dunes rest on a sand-free substrate, near an oasis in this location at 26°02' N, 26°48' E. They are generally wider and with a greater spacing (mean spacing here is 3.5 km) than the yardangs of China and Iran, and they are overall more continuous. The crestline of the dunes is apparent, while no such crestline is apparent in yardangs, and their tops are typically flat [6].

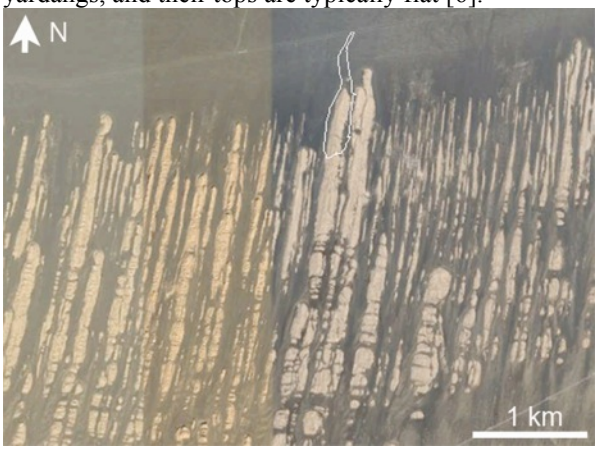


Fig. 1. A portion of Dunhuang Yardang Park, China.

Fig. 2. Yardangs of the Lut desert, Iran. ASTER image.

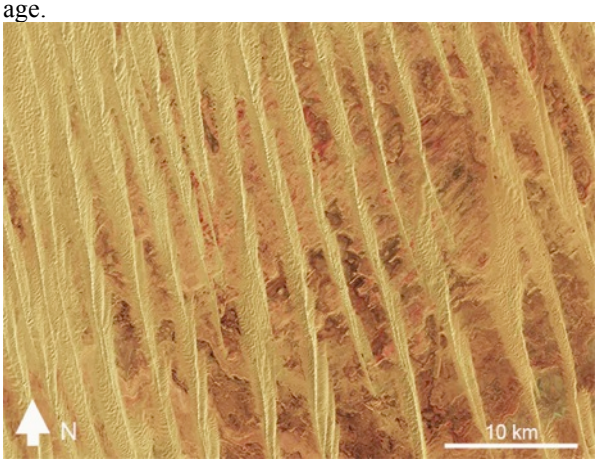


Fig. 3. Linear dunes of Egypt, Landsat ETM+.

Dunes and Yardangs of Titan: Titan has extensive linear dune fields that are similar in size, shape, and radar response to large, linear sand dunes on Earth, such as those seen in Fig. 3 of Egypt (Fig. 4) [10,6]. Two other locations at Titan's northern midlatitudes have landforms resembling yardangs (Fig. 5).

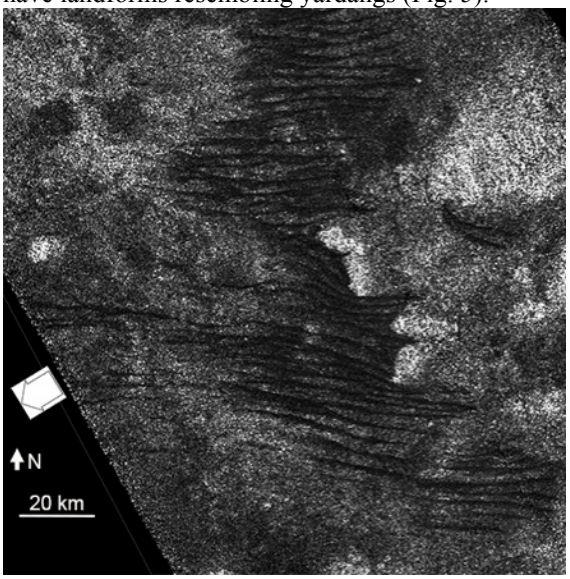


Fig. 4. SAR image of a field of short linear dunes on Titan, T23, 9.7° N, 357.5° W, similar scale to Fig. 5.

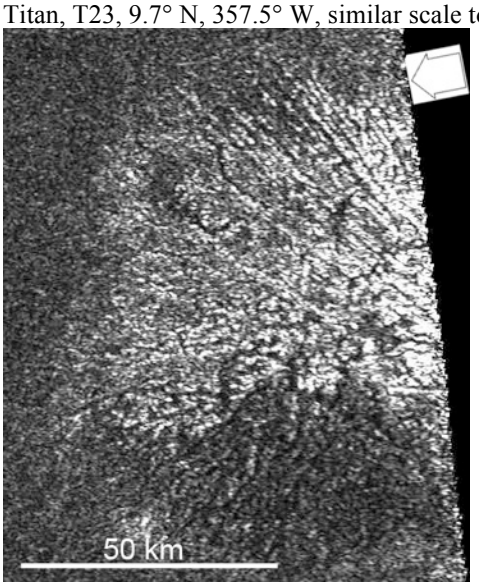
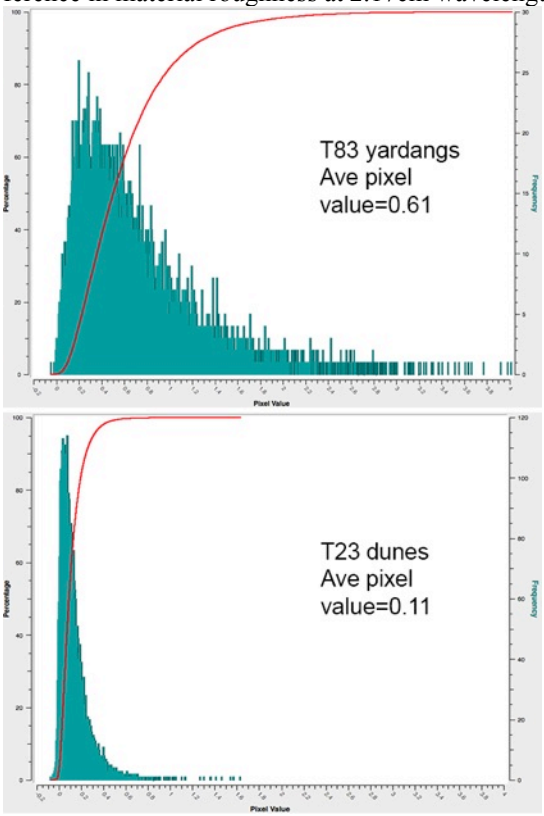


Fig. 5. Possible yardangs on Titan at 41°N, 210°W, from Cassini SAR swath T64, 12/09.

Dunes in Fig. 4 have an average length of 32 km, width of 940 m and spacing of 2.9 km, for a length:width of 34:1. The features of Fig. 5 appear to be more straight and closely spaced than the dunes, and they have an average length of 28 km. They have a mean width of 660 m (SD=230 m) resulting in a length:width of 40:1. Similar landforms seen just 10° to the E in T83 have a mean length of 20 km and a mean width of 740 m (SD=280 m), yielding a length:width of 27:1.

One significant difference between dunes and possible yardangs on Titan is their SAR brightness. A small sample of each region reveals dunes are darker to SAR (Fig. 6), similar to [8]. This is also true for yardangs on Earth [8], and reveals a fundamental difference in material roughness at 2.17cm wavelengths.



Discussion: Yardangs and linear dunes on Earth and Titan have broad similarities, but some key differences. Dunes in our study areas are generally wider than yardangs, though length:width does not seem to discriminate. Straightness and discontinuousness, currently not quantified, may be key discriminators. SAR brightnesses may be the most significant factors in determining differences between the two landforms.

References: [1] Goudie A.S. (2007) *Geography Compass 1*, 65-81. [2] Cooke R., Warren A. and Goudie A.S. (1993) *Desert geomorphology*, UCL Press. [3] Lancaster, N., Geomorphology of desert dunes (1995). [4] Ward A.W. (1979) *Jour Geophys Res 84*, 8147-8166. [5] Zimbelman J. et al. (2010) *Icarus 205*, 198-210. [6] Paillou et al., Icarus in progress (2015). [7] Greeley R. (1999) *Technical Report*, ASU. [8] Goudie A.S. (1999) in *Aeolian environments, Sediments and Landforms*, 167-180. [9] Bristow C. et al. (2009) *Geomorphology 105*, 50-58. [10] Lorenz R. et al. (2006) *Science 312*, 724-727.