TERRESTRIAL ANALOGUES OF LONGITUDINAL DUNES ON TITAN. J. Radebaugh[1], R. Lorenz[2], C. Spencer[1], and the Cassini Radar Team, [1]Brigham Young University, Department of Geological Sciences, Provo, UT 84602, jani.radebaugh@byu.edu, [2]Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723.

Introduction: Among the many features indicative of a young surface acted upon by an active atmosphere seen by the Cassini Radar instrument on Saturn's moon Titan are vast fields of dunes [1]. These fields are located mainly at equatorial regions, within ±30°, and nearly encircle the globe [2,3]. Dune materials on this icy moon are organics as suggested by their dark appearance to Radar and V-NIR instruments as well as their spectral signature [4,5]. These materials are likely snowed to the surface as solids out of an atmosphere where they were produced by photochemical processes. Winds of ~1 m/s in Titan's 1.5 bar atmosphere are able to saltate slightly smaller than sand-sized particles (0.25 mm) into dune forms [1,3].

Dunes on Titan are longitudinal in form, and have the appearance of dunes on Earth, enabling valuable comparisons to be drawn. Notably, there are not many Martian or Venusian longitudinal dune fields with which to compare Titan's dunes [6].

Dune Morphology: The Radar-dark, linear-formed dunes on Titan are 1-3 km wide, have a 1-4 km spacing, are up to 100 m high, and are several to hundreds of kilometers long (Fig. 1). These dimensions are similar to those of longitudinal dunes in the Namib and Saharan deserts (Fig. 2) [1,2].

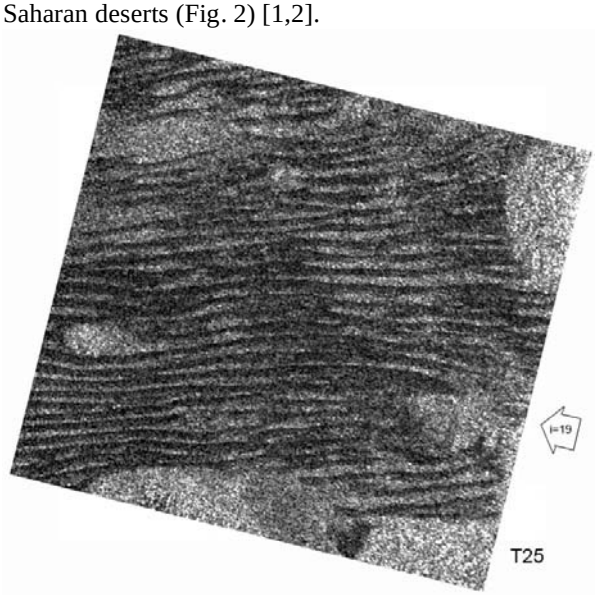

Fig. 1. Longitudinal dunes on Titan, widths ~2 km. Bright objects are probably topographically higher.

Dunes of this type form by a wide range of hypothesized wind directions [7,8,9]. Of the leading possibilities, this work favors the prevailing wind hypothesis, in which sand transportation occurs along the dune axis [10]. In this model, winds blow along one dominant direction with seasonal or minor off-axis winds.

The prevailing wind hypothesis model is, for example, best suited for dunes in the Mauritanian Sahara, where longitudinal dune axes parallel winds that blow from northern Africa out west to sea. Dunes here appear to diverge around topographic obstacles, then resume their orientations on the downwind side. High-resolution images reveal wind streaks that trail behind these obstacles (Fig. 2). Dunes on Titan show similar behavior around topographic obstacles, although image resolution (~170 m) does not enable smaller forms such as wind streaks to be visible. Some large-scale, Radar- and optically-bright features on the purported lee of obstacles have the appearance of being deposited by winds, strengthening the connection of Titan's dune fields to the prevailing wind hypothesis model. Nearly uniformly across Titan, dunes indicate that winds are primarily W-E [2,3].

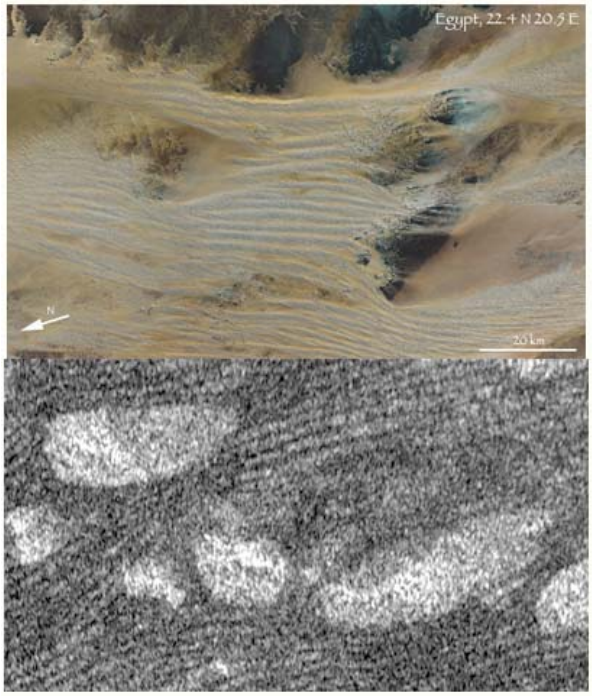

Fig. 2. Longitudinal dunes in Egypt (top) and at the equator of Titan, to scale (bottom – image from T41 flyby, 2/08).

Formation and Longevity of Titan's Dunes: Due to their sizes and location in large deserts, longitudinal

dunes are the most areally extensive dune form on Earth. Yet the formation of this dune type is not well understood, both in terms of wind and sand transportation models. One model for formation involves the elongation of one horn of a barchan dune into a linear dune [11]. This may occur when sand supply has increased in a region, given that barchan dunes often form in regions of low sand supply, while longitudinal dunes are stable in a wider range of sand supply.

Another formation model claims that complete barchan dunes can form chains in the downwind direction that merge to form a single linear dune (Fig. 4) [12]. This scenario may occur again in a condition of increased sand supply. Evidence for both of these models has been seen on Earth and Mars, and may be evident in select regions on Titan.

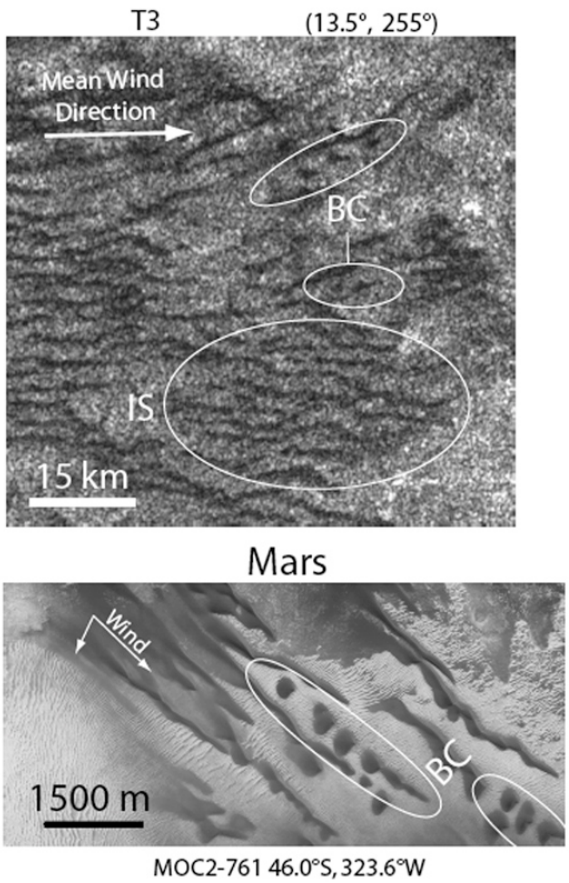

Fig. 4. Barchan convoys on Mars (bottom) and possibly on Titan. IS indicates a region of increased sinuosity, also an indicator of sand supply changes and wind variation.

Since images are only snapshots in time, it is difficult to determine the long-term evolution of a system from isolated data taken closely spaced in time, as often happens with planetary image analysis. It is possible, in fact, that the above models run the other way, if for example sand supply or winds vary from conditions conducive to longitudinal dune persistence. There is some evidence for changes in Titan's dune fields, in cases where longitudinal dunes appear to overly transverse dunes or previously existing longitudinal dunes. But given the vast majority of Titan's dunes are longitudinal, even at the edges of sand seas and at the far northern and southern reaches of dunes, where sand supply appears to be more limited, these features seem to have reached a currently stable existence.

It has been hypothesized that longitudinal dunes are at the most highly progressed end of broad dune evolutionary trends. Some large, terrestrial, longitudinal dune fields are estimated to be as old as 100,000 years [13], while other types of dune fields are typically younger by at least an order of magnitude. This idea may be bolstered by the pervasiveness of longitudinal dunes on Titan, where we expect wind and sand supply patterns are not interrupted by episodes of abrupt climate change, invasion by vegetation, or encroachment by sand-stealing oceans. Processes on Titan appear to be efficient at carrying sand-sized particles to equatorial dune-forming regions, where they are worked by winds into dunes. This is probably ongoing, as there are almost no features that can claim to overlie the dunes, despite evidence of fluids that could conceivably fill channels at polar and equatorial locations [14].

Thus, despite the proposed and observed youth of individual dunes, the dune fields of Titan may be relatively old in Titan's current climate configuration.

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