TITAN AS A LABORATORY FOR LINEAR DUNE FORMATION. C. J. Savage[1], J. Radebaugh[1], [1]Department of Geological Sciences, Brigham Young University, Provo, UT 84602, cjonsavage@gmail.com, jani.radebaugh@byu.edu

Introduction: Synthetic Aperture Radar images of Titan collected by the *Cassini* spacecraft show that dunes are abundant on Titan's surface, covering almost 20% of Titan's surface [1,2]. Nearly all of the dunes found on Titan are linear in form, are found near the equator (±30°), and have a west-east orientation. Since there is likely active linear dune formation presently on Titan [3], we can use Titan as a laboratory to study atmospheric conditions and dune processes of a younger Earth. Titan not only has active winds and a supply of dune-forming organic sediments, but where dunes form there are no large bodies of liquids, vegetation, or large topographic obstructions to disrupt global wind patterns or dune formation [1,2]. There are multiple variables that control linear dune formation, both on Earth and on Titan, including sediment supply, wind regime, basin location and dune induration (solidification) due to moisture. We present the results of a detailed morphological study of select dune fields on Titan, undertaken in order to explore possible linear dune controls on Titan and on Earth.

Problem: Dune fields on Titan are sufficiently abundant that they represent the results of major atmospheric and surface processes on Titan. Thus, a detailed analysis of these features will illuminate important relationships and processes. Large-scale dune orientation surveys [4] feed directly into global models for atmospheric transport and wind. Detailed studies on a discrete sand sea region (covering several hundred square kilometers on Titan) provide information on small-scale wind transport, wind interactions with topography, and variations with latitude, related to climate differences on Titan.

In addition to furthering our understanding of Titan, studies of dune processes on Titan will apply directly to our understanding of dunes on Earth. Linear dunes are the most common desert dune form on Earth, accounting for up to 40% of Earth's desert dune forms [5] and usually occurring in extensive dune fields. Despite their abundance, the processes that form them are not well understood. Since dunes cover such a large part of the Earth's and Titan's surfaces (up to 10% and 20% of the total land surface respectively) and form part of the sediment transport system, an understanding of dune processes contributes directly to an understanding of sediment concentration, transport and wind-surface interactions [6]. Many of the linear dunes we observe on Earth were likely formed during the Pleistocene (1.8 million to 10,000 years ago; [7]) when climatic conditions were more favorable for linear dune formation. Titan could thus prove to be a valuable laboratory for understanding now-dormant linear dunes on Earth.

Methods: Dunes appear dark to Cassini's 2.17 cm Radar due to absorptions by the dune-forming particles, while interdune areas are light due to scattering by fractured, mostly water-ice bedrock. We analyzed several aspects of dune morphologies, using the USGS program ISIS, including (1) dune widths, (2) dune spacing and (3) global dune field locations. Width and spacing measurements along individual dunes on radar swath T25 from 22ºS lat. to 19ºN lat. (in a narrow longitudinal band near 30ºW) were made at approximately 5 km intervals (suitably closely spaced, as corroborated by test measurements at 1.76 and 0.8 km intervals). Since most dunes are many times longer than 5 km, this frequency ensures complete dune coverage. Widths were measured from one light/dark boundary to the next across radar-dark areas perpendicular to the long axis of the dunes. A similar measurement scheme was used to measure interdune spacing across light areas that are perpendicular to the long axis. These measurements were then plotted against latitude to look for indicators of dune variation from one area to the next which could be responses to changes in sand supply, wind regimes, basin location or moisture.

Results: The data show that dune widths and spacings are highly variable at every latitude, in some areas ranging from 0.28 km to more than 2 km (Fig. 1). Even with this range and variability, there is a broad correlation between latitude and dune width. Dunes tend to widen away from low latitudes, areas of presumably high sedimentation. This trend is especially pronounced in the southern latitudes where average dune widths are at least 1.27 km compared to latitudes north of the equator which have average widths of 0.82 km.

Additionally, there does not appear to be a trend of either dune widening or thinning toward the center of any one dune field like the one visible on T25 between 11ºN lat. and the equator (Fig. 2). Instead, average dune widths are consistent across the dune fields thus far measured. Average dune widths for the field illustrated in Fig. 2, for example are 0.7 to 0.8 km, while they are wider on average for dune fields south of the equator.

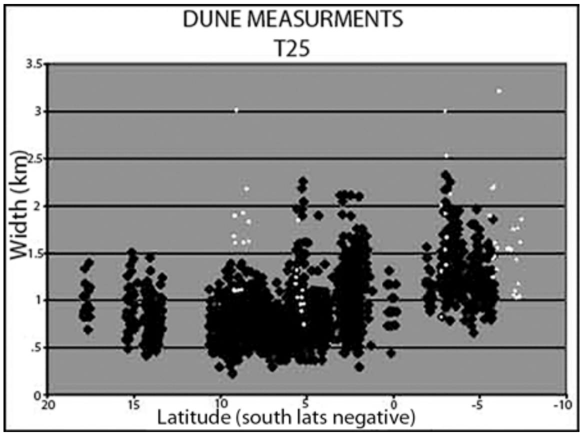

***Fig. 1** – width(in km) plotted against latitude from swath T25. Black diamonds represent dune widths and white circles represent dune spacings*

Dune spacings are also extremely variable, and have similar size ranges as for widths. Preliminary results indicate that dune spacings are greater at the north edges of dune fields than the south (Fig. 1).

Some uncertainty was introduced as a result of quantization problems associated with the image analysis, but it is not clear exactly how these quantization errors have effected the outcomes. Future studies will ascertain if the quantization represents a true natural phenomenon or is simply due to rounding errors in ISIS.

Results from nearby swaths (T28, T29) will also be presented. Future studies include all dunes seen on Titan by Cassini Radar, up to several percent of Titan's surface.

Discussion: Parteli [8] suggests that induration (by ice, minerals or moisture) of the dunes may play a role in linear dune formation. If induration by moisture is occurring, it could be hindering sedimentation and restricting dune growth. The southern hemisphere is at least currently a dryer area (evidenced by the fact that "lakes" of liquid methane are not present like in the northern hemisphere; [9]), which would allow for less restricted sediment transport. It is possible that increased sediment mobility in the southern hemisphere allows dunes to grow wider than those in the northern hemisphere. If sediment is restricted in the north, we might expect to continue to find smaller spacings and widths north of the equator than south, though more measurements are needed to confirm this.

Further work is needed to better understand how moisture, or the lack thereof, and other factors have contributed to dune formation. Studies of the relationship between dune width and spacing may prove as fruitful as other studies between dune width and height [6]. A detailed morphological study of Earth dunes will be needed to establish such correlations. Further comparisons of Earth and Titan dunes will certainly be required to better understand how linear dune widths and spacings have been affected by sediment supply, wind regime, basin location and dune induration due to moisture.

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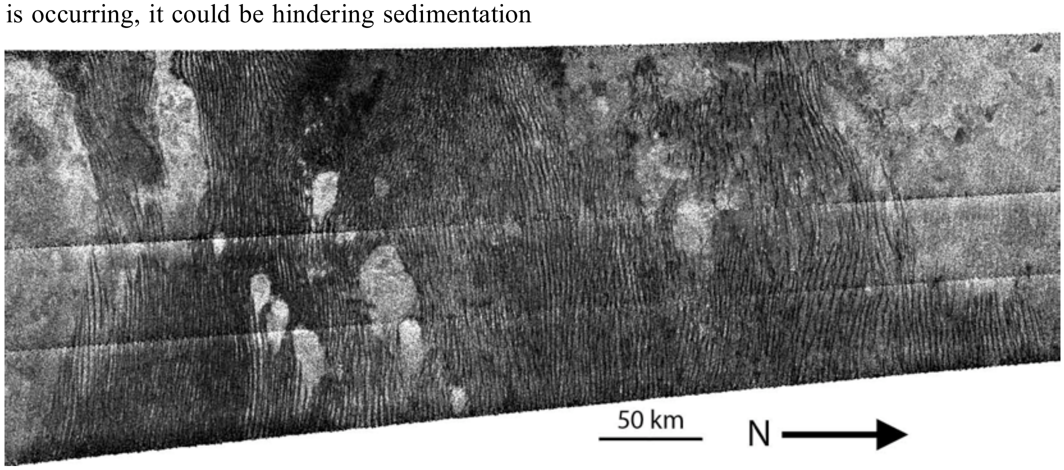

***Figure 2** – Dune field from t25 between 10ºN (right) and the Equator (left). Illumination is from the W.*