GRAIN SIZES OF DIFFERENT TITAN LAKE BEACH LOCATIONS AND POSSIBLE ORGANIC INFLUENCES. K. Dzurilla[1], C.J. Ahrens[1], V.F. Chevrier[1]. [1]Arkansas Center for Space and Planetary Sciences, University of Arkansas, Fayetteville, AR 72701 (kadzuril@uark.edu).

Introduction: Titan's lakes and seas across the surface contain valuable information regarding the landscape evolution and dynamics of liquid compositions at such extreme conditions relative to Earth. However, from Cassini radar studies [1-4], the large amounts of bodies of hydrocarbon lakes reveal similar patterns and beach morphologies (Figure 1). However, the morphology of the beaches surrounding these great lakes in the polar regions are still being investigated [5-6] while equatorial lakes are best explained as supplementary subterranean sources (i.e., oases) [7], though still saturated by dune fields. It should be noted that the equatorial portion on Titan has an increased amount of tholin-hydrocarbon production, mainly within the dunes [4,7], potentially influencing the lake morphology constraints.

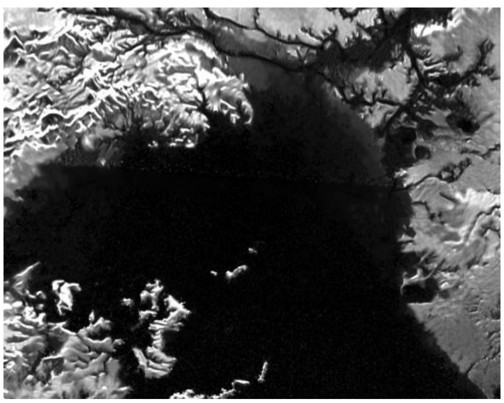

Figure 1: Despeckled Cassini Synthetic Aperture Radar (SAR) view of Ligeia Mare, one of the largest hydrocarbon seas on Titan. Image credit: NASA/JPL-Caltech/ASI (2015).

Organic molecule production has been observed in the atmosphere of Titan. These organic grains are a result of radiation interacting with the simple hydrocarbons present in the upper atmosphere. Particles after creation will continue to grow as they move through the atmosphere towards the surface. Particle characteristics vary as their formation processes are dependent on environmental factors. Previous studies [8-9] have found a relationship between thermal inertia and grain size as demonstrated in Equation 1.

$$k = (C * P^{0.6})d^{-0.11\log(\frac{P}{K})} \qquad 1.$$

In this equation, thermal conductivity is represented by k, the diameter of the grain shown by d, pressure at the surface by P, and C and K are constants of 0.0015 and 0.00081 torr respectively. For the calculations in the study, we used a pressure (P) of 1102 torr.

The latest study by MacKenzie et al. 2019 [10] gave us maps of thermal inertia across the Titan surface. These values can give us clues as to the grain sizes at play for the different polar and equatorial beaches. Understanding these grain sizes can help us understand the morphological evolution of such large (or constrained) lakes. Our objective is to calculate the grain sizes at various large lake locations across Titan (namely polar versus equatorial) to guide us toward an understanding of beach morphological constraints and investigate the equatorial lakes with organic grains.

Methods : The surface of Titan contains a diverse spectrum of topography. Thermal inertia values varied based on the unique geomorphological units [10] (Figure 2).

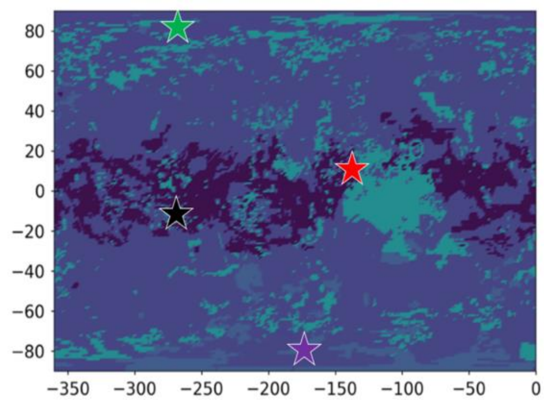

Figure 2: Thermal inertia map of Titan with our current study locations marked (colored stars). The colors correspond to calculated curves in Figure 3-4. Thermal inertia map from [10].

By utilizing the thermal inertias of individual units and Equation 1, we can determine the grain size in different beaches across Titan. We picked four different locations across Titan (Figure 2 stars). The four locations we chose represented differences in polar regions and equatorial landscapes that could potentially influence the grain size structure of the beaches and hydrocarbon lakes. The traverses were measured at the lake perimeter (rim to rim of the lake) including a 150 km perimeter to include the beach environment.

Results: Using Equation 1, we calculated different grain sizes in the 6 different types of terrains described in [10]. These values are shown in Table 1.

Terrain Types	Grain Diameter (μm)
Lakes (still)	0.39
Lakes (conv.)	0.000014
Dunes	4.76
Hummocky	0.0085
Labyrinth	0.26
Plains	0.83

Table 1: This study's calculations of grain sizes from different terrain regions of Titan as stated in [10].

Ligeia Mare (north polar lake) and Ontario Lacus (south polar lake) share similarities in the beaches having a relative medium to fine grain size (0.25 – 0.92 μm) (Figure 3). Interesting to note that in Figure 4 showing convecting lakes (only in the polar lake regions [10]), these polar lakes have a major decrease in particle size at the lakes. For the equatorial lakes in our study, we find that these lakes are surrounded by dunes, having a much higher grain size (relatively coarser) and larger variability in beach grain size overall (4.4 – 4.7 μm) (Figure 3-4).

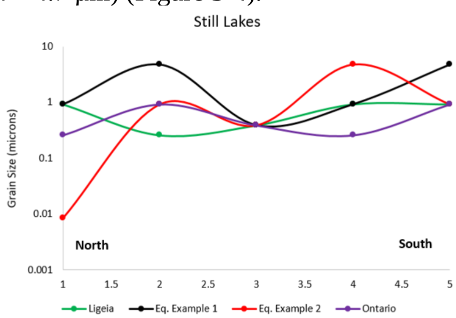

Figure 3: Lakes from our study with relative calculated grain sizes. X-axis represents a traverse point across each diameter of the lake. Y-axis is calculated grain size in microns. The still lakes portion is in Traverse #3.

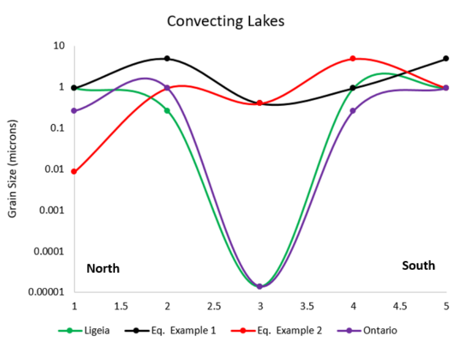

Figure 4: Similar to Figure 2 in that the polar lakes are now within the "convecting" regime from [10]. The lakes portion is in Traverse #3.

From these results we found that grain size generally increases with decreasing distance to convecting lakes in the polar regions. This gives us a clue as to the coarser grains of the polar beaches confining these great methane lakes. Little grain size variability (as with still lakes) lacks the dynamics of volatile transportation, whereas a larger difference in grain sizes (convecting lakes) gives us a more dynamical view of how these polar lakes could transport volatiles through proposed aquifers or surface-atmosphere interactions. The variability in the equatorial lakes with much coarser grain sizes also gives us insight to the constraint of why these lakes may not be large enough to detect with simple imaging instrumentation, though estimated of their existence from Cassini radar [7]. Larger coarser grains could also add a more transitional (or rather lack of mobility) variable in that these lakes may be transient or seasonal, and that the diameter of organics is affected based on these variations.
With that noted, the variability of these polar lakes including smaller grains at the beach perimeters serves as a starting point for investigating the mobility of organic and Titan sand-like materials and proposed aquifer-type morphologies.

Conclusions: Understanding size diversity in different topographic areas can provide a better beach sediment profile and its influence on the area morphology. NASA's New Frontiers Mission, Dragonfly, will provide further information on the chemical composition of surface samples taken from different landing sites [11]. Data obtained from this analysis could provide better answers as to organic grains and their size variations, and their influence on Titan landscapes.

References: [1]C. Elachi *et al.*, (2005) *Science (80-.).*, vol. 308, no. 5724, pp. 970 LP – 974. [2] J. W. Barnes *et al.*, (2013) *Planet. Sci.*, vol. 2, no. 1, pp. 1–22. [3] C. C. Porco *et al.*, (2005) *Nature*, vol. 434, no. 7030, pp. 159–168. [4] R. D. Lorenz, et al. (2006) *Science (80)* vol. 312, no. 5774, pp. 724–727. [5] E. R. Stofan *et al.*, (2007) *Nature*, vol. 445, no. 7123, pp. 61–64. [6] G. Mitri, *et al.* (2007) *Icarus*, vol. 186, no. 2, pp. 385–394, 2007. [7] C. Griffith, et al. (2012) *Nature*, 486, 237-239. [8] H. Charles et al. (2017) *Earth and Planetary Science Letters*, 458, 152-160. [9] M. Presley, P. Christensen (2010) JGR, 115, E07004. [10] S. M. MacKenzie *et al. J. Geophys. Res. Planets*, vol. 124, no. 7, pp. 1728–1742, 2019. [11] R. D. Lorenz *et al.*, *Formulation of the Dragonfly Concept*, 2018.