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Lacustrine Geomorphology on Titan; Glimpses into the Evolution of Titan's Polar Landscapes over Multiple Timescales

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Titan's hydrocarbon lakes and seas express a range of morphologic characteristics that suggest a rich history of change operating on seasonal, millennial, and geologic timescales. We will present a review of observed lacustrine morphologies, describing both the distribution of and interaction between lake basins, shoreline features and fluvial drainage networks found in the North and South Polar Regions. While Cassini has directly observed seasonal variation in the southern lakes, longer timescale variations must be inferred from the interaction between geologic features. Features interpreted as topographic benches in the north and paleoshorelines in the south suggest base level changes on millennial timescales while the orientation between sea shorelines and nearby drainage networks implies regional variations over geologic timescales. A process-based study of these relationships reveals important information pertaining to the paleoenvironment, paleohydrology, and topographic evolution of Titan's polar landscapes.

Lakes are found both with and without associated drainage networks, have shoreline transitions varying from sharp to diffuse, include a variety of plan-form shapes ranging from near-circular to highly-irregular, and have surface areas than span from the limits of detection ($\sim 1\ \mathrm{km}^2$) to more than $10^5\ \mathrm{km}^2$. The largest seas in the north, including Ligeia, Kraken and Punga Mare, accommodate shallow bays where upland channels terminate into well-developed drowned river valleys, thus showing a transition from well drained to swamped topography without sedimentation keeping pace with the rising relative base level. Nearby fluvial systems include drainage networks that run parallel to sea shorelines, suggesting the existence of a widespread drainage system that predates the large-scale, and apparently non-uniform, down-dropping of topography responsible for sea formation. Similar morphologic relationships are observed in the lowest portions of the south, revealing boundaries that may represent paleoshorelines which encompass areas comparable to their northern counterparts. Here we also see evidence of a pulse of channel incision (due to relative base level lowering) that has propagated across a pre-existing less dissected plain sloping away from the advancing channel network.

While the larger seas are morphologically consistent with drowned topography the smaller lakes, which have median area of $77 \pm 20\ \mathrm{km}^2$, originate through other processes. The formation mechanisms responsible for these features are not well understood. Where available, topographic data suggests empty lake basins are steep-sided and 150-300 m in depth. Proposed mechanisms for creating these depressions include impact, volcanic, dissolution and/or solution-based processes. Glacial and most periglacial processes are likely thermodynamically restricted. However, each of the currently proposed mechanisms has significant problems. The irregular shape of many lakes, the non-stochastic size distribution, and the concentration in polar regions argues against impact and volcanic-based processes. The karstic dissolution model requires the upper crust to contain a substantial amount of material that is soluble in liquid hydrocarbon and solution-based processes (e.g. gnamma holes) required an efficient method of removing weakened material. As part of our review of lacustrine morphology, each of these formation mechanisms will be discussed in the context of the distribution, shape and structure of the observed lakes.