

TITAN: CAN FLUVIAL EROSION PATTERNS TELL US ANYTHING ABOUT INITIAL LANDFORMS AND REGIONAL LANDSCAPES? J. M. Moore¹, A. D. Howard², P. M. Schenk³, and R. T. Pappalardo⁴ ¹NASA Ames Research Center, MS 245-3, Moffett Field, CA, 94035, jeff.moore@nasa.gov, ²Department of Environmental Sciences, University of Virginia, Charlottesville, VA 22903, ah6p@virginia.edu, ³Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058, schenk@lpi.usra.edu, ⁴Jet Propulsion Laboratory, MS 183-301, Pasadena, CA 91109, robert.pappalardo@jpl.nasa.gov

Introduction: As we have previously hypothesized, Titan's interior may be endogenically inactive. Those landforms on Titan that are unambiguously identifiable can be explained by exogenic processes (aeolian, fluvial, impact cratering, and mass wasting) [1,2]. At the scale of available imaging data, the surface is dominated by aeolian and fluvial erosion, transportation, and deposition. Here we report on our initial effort to directly address the recognizability of endogenic landforms subjected to Titan's weather by employing computer simulation of long-term landform evolution principally from fluvial activity. We use a landform evolution model [3] to simulate fluvial and lacustrine modification of icy satellite landscapes to evaluate whether fluvial erosion of representative initial landscapes (e.g., the icy Galilean satellites) can replicate the present Titan landscape.

Approach: We ask the questions to what degree can the formative processes and morphology of an initial endogenic or cratered landscape be inferred after sufficient modification by fluvial erosion as to resemble Titan's surface? How much erosion would have had to occur to make inferences about the nature of the initial landscape impossible? Our goal is to determine: (1) the existence and recognizability of endogenic processes on Titan; (2) the relative dominance and nature of fluvial activity over the landscape; (3) the expression and rates of landform erosion and sediment redistribution; and (4) the specific morphological expressions of modified endogenic landforms

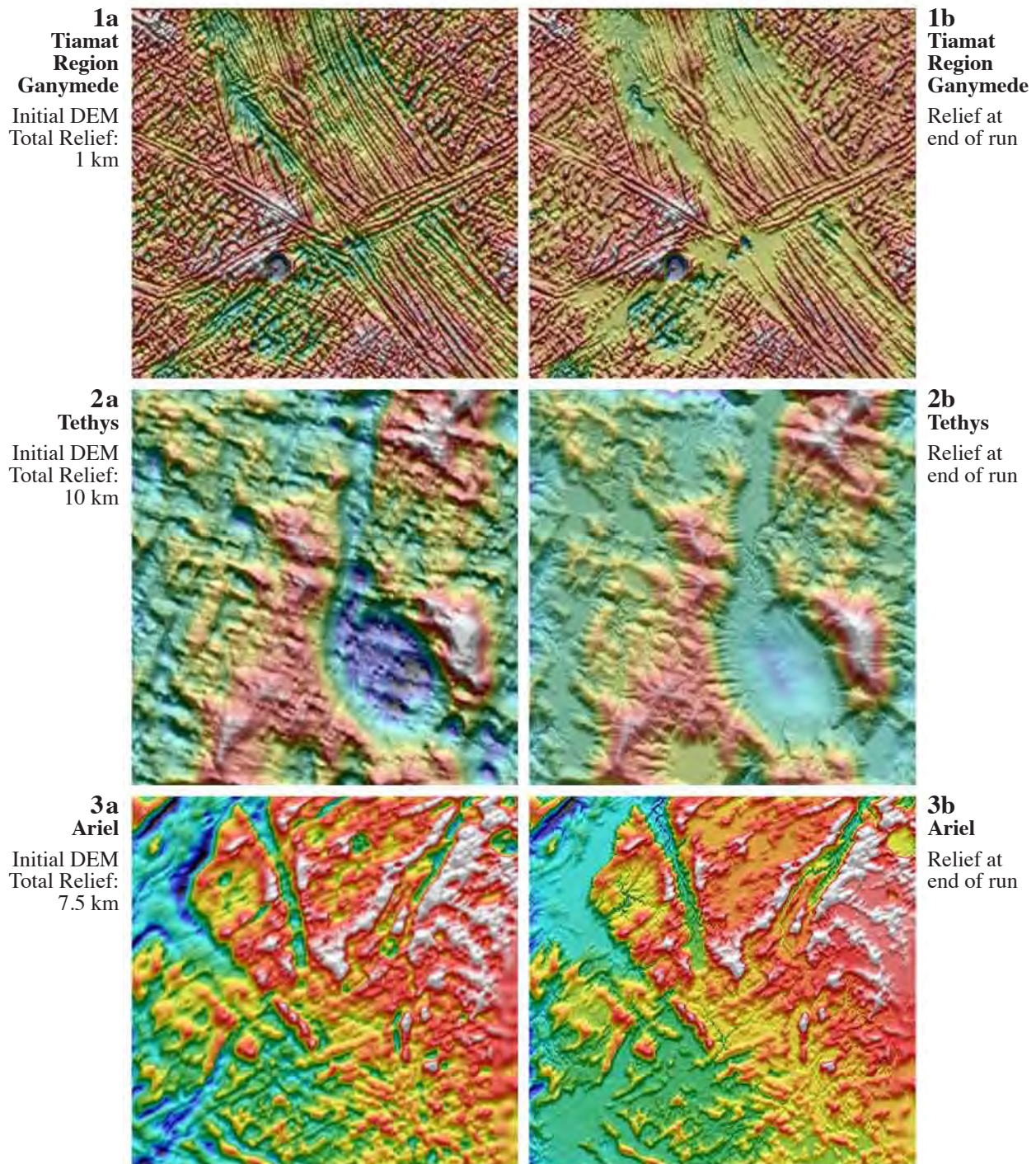
We employed our landform evolution model (LEM) to simulate fluvial and lacustrine modification of three initial landscapes: (1) A mixture of endogenic belts and zones with blocks of older cratered terrain but little regional relief (Ganymede); (2) A regionally high-relief landscape dominated by cratering (Tethys); and (3) A landscape with both endogenic and cratered regions separated by substantial regional relief (Ariel). We used high quality Digital Elevation Models (DEMs) generated from stereo imaging of the targets for these initial landscapes [e.g., 4].

Initial Model Assumptions: For our first runs, we assumed complete runoff, so that depressions become lakes, and drainage exits somewhere along edges of simulation domain. Edges of simulation domain were fixed (non-erodible). Flow rates were scaled to Titan gravity. Rate of channel incision was set to be propor-

tional to shear stress on bed (parameterized as a power function of discharge and gradient). Weathering in the model produced transportable debris. Sediment was deposited in low-lying areas, producing alluvial fans and infilling depressions from the edges inwards in deltaic deposits. We assumed little fine suspended sediment deposited in lakes. In LEMs the spatial pattern of erosion does not vary much with different parameters but the rate of erosion is very affected. For the purposes of these initial trials, the *pattern* not the rate, was deemed most important.

Preliminary Conclusions: Landform Evolution modeling of fluvial erosion suggests that the overall regional relief (typically >1 km) of icy Galilean satellites is too little to initiate large-scale fluvial dissection and integrated valley network formation (Fig. 1). This same modeling suggests that icy satellites with large regional relief (on order 10 km) are susceptible to large-scale fluvial dissection and valley network formation (Figs. 2 & 3). If these model results are indeed relevant to Titan, they indicate that drainage patterns were initiated when Titan had substantially more *regional* relief than the icy Galilean satellites. A variant of this conclusion would be Titan's topography could be formed by long-term erosion competing with tectonic warping occurring over broad (100's of km) spatial scale. The possibility that Titan has supported greater regional topography relative to that seen on icy Galilean satellites implies that Titan had a stiffer crust. Titan large-crater morphology is consistent with this conclusion. However, we note that some polar lake shores resemble the lakes formed in our Ganymede simulations (Fig. 1b), suggesting that perhaps portions of the polar regions have lacked significant regional topography during the era of these lakes formation.

References: [1] Moore, J. M. and Pappalardo, R. T. (2008) Titan: Callisto with weather? *AGU, Fall Meeting 2008*, abstract #P11D-06. [2] Moore, J. M. and Pappalardo, R. T. (2009) Titan: An exogenic world? *in prep.* [3] Howard, A. D. (2007) Simulating the development of martian highland landscapes through the interaction of impact cratering, fluvial erosion, and variable hydrologic forcing, *Geomorphology*, doi:10.1016/geomorph.2007.04.017. [4] Schenk, P. M. (2002) Thickness constraints on the icy shells of the Galilean satellites from a comparison of crater shapes. *Nature* 417, 419-421.



Figs. 1a & b. At the end of the Ganymede run, there are no long, deeply-incised valleys but there are extensive alluvial plains. Some depressions remain unfilled – hosting lakes. The remaining depressions (lakes) have well-defined shorelines (encroaching delta fronts) that resemble some of the depressions (lakes and dry lakes) in the polar regions of Titan.

Figs. 2a & b and 3a & b. Where there are large-scale contrasts in relief, as in both Tethys and Ariel, (e.g. cratered landscapes or broad uplands), long valleys systems can develop. This suggests that the initial topographic relief on Titan featured broad uplands and lowlands and little ubiquitous fine-scale tectonic structuring, as inferred from the well-integrated drainage networks seen on Titan.

Figs. 3a & b. Regional topography can be the result of large-scale tectonic activity as seen here on Ariel, which could either precede fluvial activity or compete with it (e.g., fluvial erosion and deposition verses endogenic increases in topographic relief).