LARGE LANDSLIDES ON ICY SATELLITES: NEW EXAMPLES FROM RHEA AND TETHYS.

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Introduction and Background: Massive ice avalanches on saturnian satellites exhibit a behavior similar to long-runout landslides found across the solar system [1-5 and references therein]: some mechanism (or mechanisms) apparently reduces the material's friction, allowing the landslides to travel 10-30 times their drop heights (*H*; as opposed to ~2x for a more "normal" frictional regime). These landslides achieve immense runout lengths (*L*), even over variable slopes and topography. Long-runout landslide observations on Earth and Mars (principally in Valles Marineris) have inspired many theories of how friction could be reduced [see summary in 1].

The drop height-to-runout length ratio, *H/L*, is commonly used as an approximation for the friction coefficient of landslide material. On Earth and Mars, there is a trend for decreasing *H/L* with increasing landslide size (see Fig. 1). Large landslides on Iapetus, however, do not follow this trend; instead, the values scatter between 0.1 and 0.3. In [1] we discuss how this lack of dependence of *H/L* on *L* is consistent with rheological control by modest dry friction within ice rubble that has been frictionally flash heated such that surfaces are slippery (but not melted). The implication is that tectonic fault friction on icy bodies may likewise be similarly reduced.

Cassini images continue to reveal more long-runout landslides on saturnian icy satellites. Here we extend our previous results to include two large and somewhat unusual landslides on Tethys, a moon where landslides had not been previously observed, and also include two additional landslides in Rhea's large, fresh crater Inktomi.

New Landslide Observations: Base mosaics and stereo-derived topography were generated by PMS from Cassini images. As in [1], heights and lengths were measured from the head of the scarp to the top of the landslide toe.

The new Tethys slides are shown in Fig. 2 at 250 m px^{-1}. Two large landslides (19 and 13 km in length) extend away from a crater ~13 km in diameter (centered at 6°N, 187°W). These Tethys slides are unusual in that they are only found in this spot (no others identified so far in other images of Tethys) and that they originate on the exterior rim of a mid-sized crater. The landslides observed on Iapetus fall from very large basin walls, the mountainous equatorial ridge, or are found *inside* some mid-sized craters. This

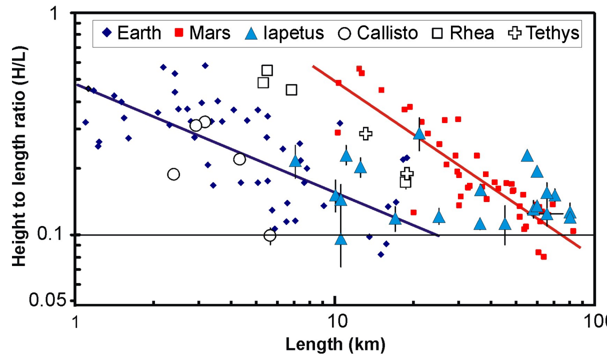

Figure 1. Landslides across the solar system: shown are measurements for 1) terrestrial subaerial landslides (from [6]), 2) martian landslides in Valles Marineris [5], 3) debris aprons within several craters on Jupiter's moon Callisto [1], 4) landslides within two young craters on Rhea (two from [1] and two new to this work; shown in Fig 3.), and 5) the two landslides identified on Tethys (shown in Fig. 2). *H/L* and *L* are proxies for the coefficient of friction and volume, respectively.

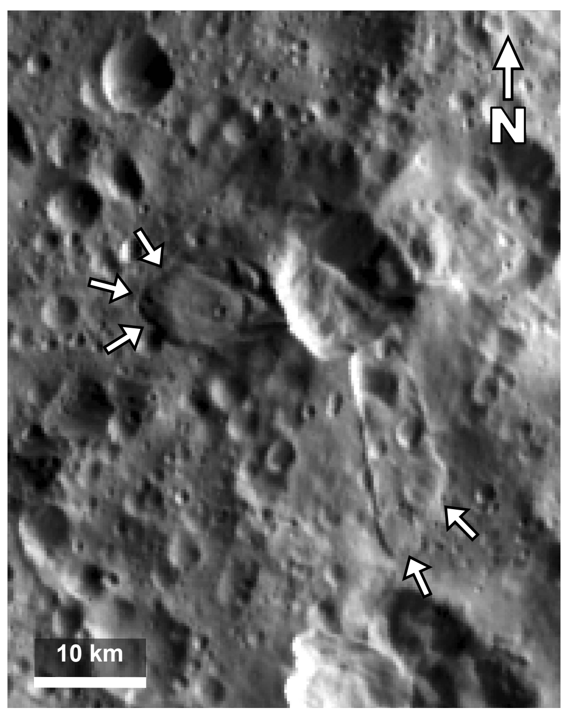

Figure 2. The two landslides identified on Tethys, to date, originate from a crater that formed on a locally high (~2-3 km) rise. Image resolution: 250 m px^{-1}.

13-km crater on Tethys apparently formed on locally high-standing terrain, and later impacts may have triggered sliding down the rise the crater formed on. The material that formed the southern avalanche appears as a veneer over pre-existing topography (see muted crater shapes in Fig. 2), and shows raised lateral margins (implying increased friction along the margins).

The southern portion of Inktomi crater on Rhea (48-km diameter; centered at 111°W, 11°S) was imaged at 38 m px^{-1} (Fig. 3). This high resolution view revealed the details of massive slumping along a large portion of the crater wall (seen on the right side of Fig. 3) and also small landslides (~5-7 km in length) at the base of a more intact portion of the southeastern wall. These landslides are similar to ones previously measured near the northeastern wall (see supplement of [1]).

Discussion: Landslides on Tethys and Rhea do appear to lie on a similar trend and show a decrease in *H/L* with *L*, however, there are too few data points to draw strong conclusions. Overall, the *H/L* values for the largest of these landslides are within the range seen on Iapetus, and confirm that the effective coefficient of friction for icy material can be quite low for material moving at high speed (*H/L* = 0.19 for the longest Tethys slide, and *H/L* values as low as 0.11 are observed for landslides on Iapetus). These friction coefficients are considerably lower than those measured in the laboratory for cold ice exhibiting stick-slip behavior at lower velocities [7].

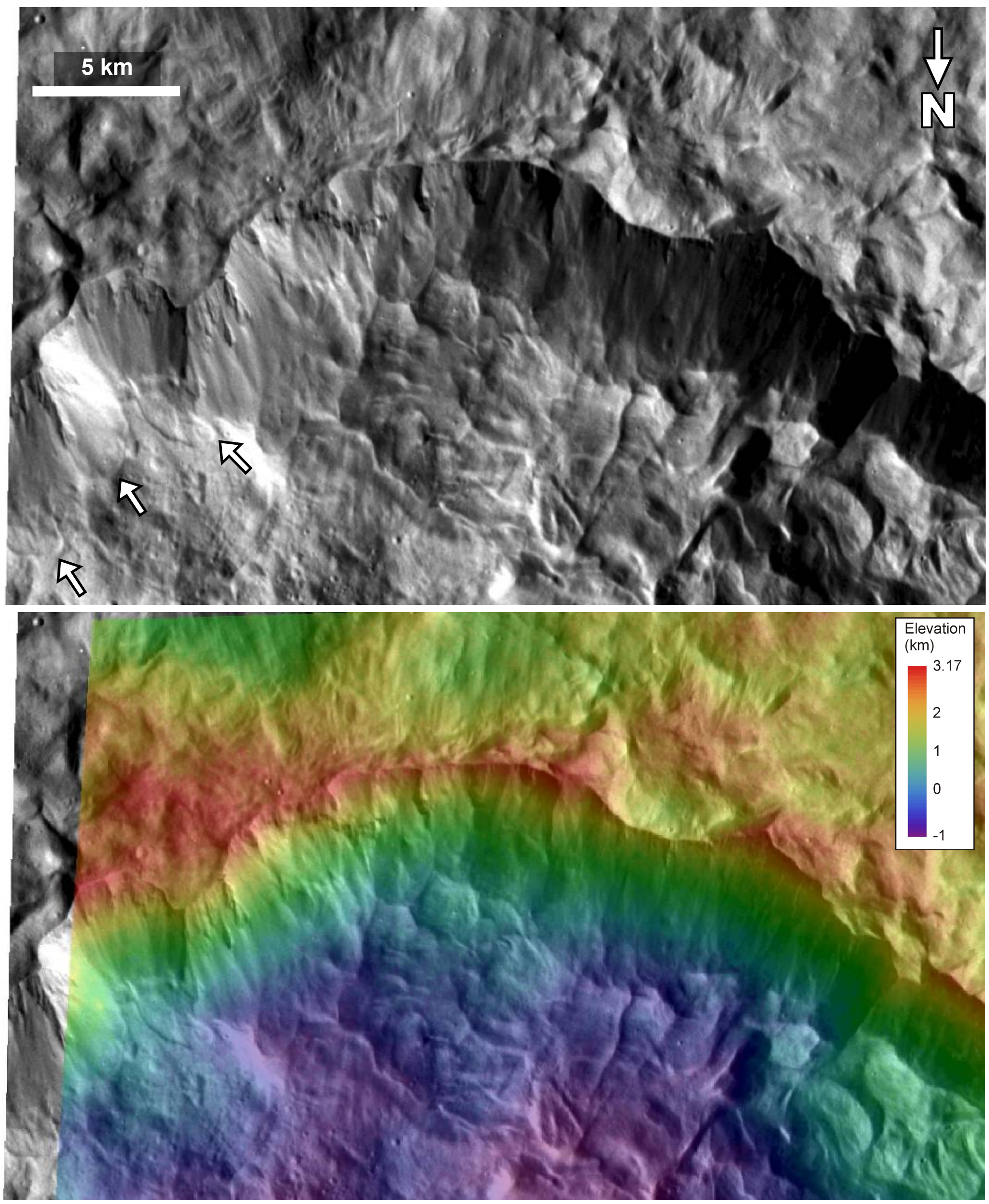

Figure 3. Southern portion of Rhea's Inktomi crater exhibiting massive wall slumps and also landslides (frontal margins indicated by arrows). Image resolution: 38 m px^{-1} with stereo topography overlain below.

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