**Tectonic Resurfacing Processes on Ganymede, Insights From Physical Models.** D. W. Sims[1], D.Y. Wyrick[1], and R. T. Pappalardo[2], [1]Dept. of Earth, Material, and Planetary Sciences, Southwest Research Institute®, 6220 Culebra Rd., San Antonio, TX, 78238, dsims@swri.org, [2]Jet Propulsion Laboratory, Pasadena, CA 91109.

**Introduction:** Grooved terrain on Ganymede generally occurs as individual lanes and polygonal cross-cutting swaths of bright terrain. Internally, grooved terrain swaths consist of parallel to sub-parallel ridges and troughs at a variety of scales; the ridges and troughs generally show similar morphology, size, and orientation. Grooved terrain on Ganymede has been interpreted by most authors as the product of fault-accommodated, distributed crustal extension, possibly accompanied by cryovolcanism [1-5]. It is generally assumed that Ganymede's lithosphere is a thin (~2 km), brittle, upper crust of predominantly water ice above an icy ductile horizon. Fault scarps are clearly observable in images of Ganymede's surface, indicating that the uppermost crust deforms as brittle material.

Fault spacing on Ganymede has been interpreted as proportional to lithospheric thickness [4]. Dombard and McKinnon [6] modeled multiple wavelength instabilities of magnitudes similar those interpreted to occur on Ganymede. The results of their models are consistent with their assumption [after 5] that the lithosphere is fractured on a scale smaller than ridge-and-trough system wavelengths. Our physical models show faulting and fracturing on a scale smaller than the relatively large displacement faults that bound ridge and trough systems [7]. Studies of fracture (joint) spacing in layered rock on Earth show a range of both linear and non-linear proportional relationships between joint spacing and layer thickness [8,9,10]. These studies, most often confined to rock layer thickness of less than two meters, suggest that spacing is influenced by layer thickness, structural position, and mechanical properties of the rock [11]. These fractures are often confined to strong layers and do not pass through weaker, less cohesive layers. Terrestrial fracture data show that the relationship between bed thickness and fracture spacing varies widely with structural position, even within the same geologic formation [9].

**Methodology:** We use physical analog models to simulate the formation of grooved terrain by normal faulting in response to distributed extension in a brittle layer over a horizontal detachment surface [11]. The brittle lithosphere is represented by a 1 to 2.5 cm constant-thickness claycake that deforms by faulting and behaves as a time-independent material at the strain rates interpreted for crustal processes. Extension is distributed across the claycake by a rubber sheet at its base.

**Results:** Fault dip and fault spacing are important variables for estimating extension. Fault dip and spacing exhibit strong control on surface morphology and topography, including ridge and trough symmetry, slope angles of both the fault scarp and the upper free surface of half-graben fault block, and the magnitude of topographic relief [5]. Our physical models show that initial fault dips of 60-80° result in surface morphology that closely mimics the ridge and trough systems observed on Ganymede (Fig. 1). Topographic relief resulting from fault displacement increases proportional to the horizontal component of fault displacement (heave) and to the magnitude of fault dip. For a given heave, steep or high angle faults produce more topographic relief than do low angle faults, which may result in an overestimation of extension where topographic relief is the only metric for fault displacement.

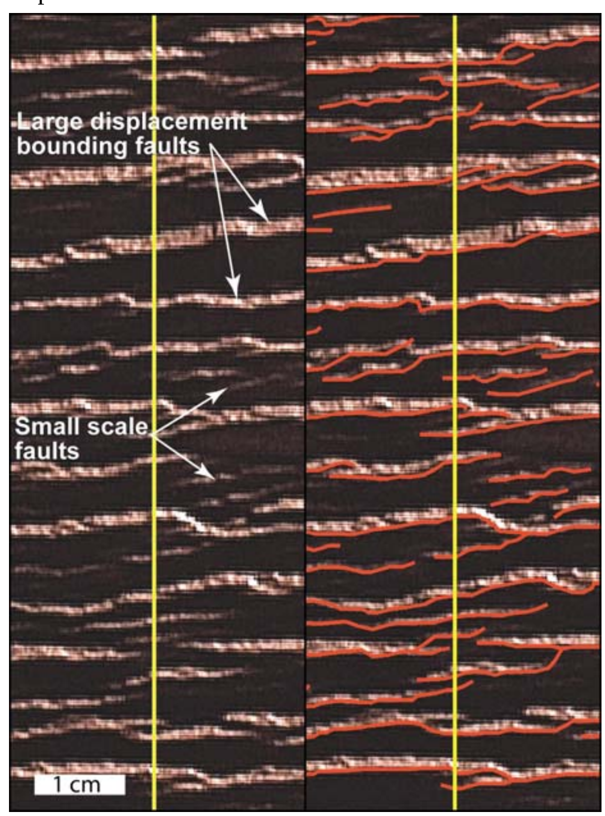


*Figure 1. Model fault development showing both large displacement bounding faults and small scale faults.*

*Red lines are interpreted footwall traces. Yellow scanline is parallel to extension direction.*

Further, where crustal thinning or necking is accommodated by brittle faulting, steep faults are more efficient because small horizontal displacements translate to large vertical displacements.

Rotated block faulting, such as is interpreted to occur on Ganymede, requires a relatively weak zone at some depth to accommodate fault-block rotation. In our models, this weak zone is represented by the rubber sheet at the base of the model layer. On Ganymede, the simplest case would be that the weak zone or detachment is the lower boundary of the lithosphere. Our models represent this simple case of a single weak layer at the base of the rotated fault blocks. However, we do not infer that faulting on Ganymede must necessarily be rooted at the base of the lithosphere.

Fault spacing on Ganymede is mappable to the limit of image resolution. The thickness of Ganymede's lithosphere is generally accepted to be less than ten kilometers, and often interpreted to be on the order of a few kilometers [4]. Our models are scaled to represent layer thickness of a few kilometers or less. The claycake in the pre-deformation state may be considered homogeneous and isotropic, and experimental results are reproducible. This provides assurance that the effects resulting from change of a single variable, such as layer thickness, can be isolated, thus giving insight into thickness and fault-spacing relationships on Ganymede.

Preliminary model results suggest a relationship between layer thickness and fault spacing. Figure 2 shows results from 1, 2, and 2.5 cm thick claycake models. Each model represents a distributed-extension (25%) half-graben system. Spacing is measured parallel to extension direction (Fig. 1), and only large-scale faults that bound ridge and trough systems are considered. The number of samples for each model ranges from 24 to 40. Figure 2 suggest a relationship between layer thickness and fault spacing. Although these data are too few to draw firm conclusions, they strongly support a relationship between fault spacing and lithospheric thickness. A regression line is plotted for illustrative purposes only.

**Conclusions:** Results from physical modeling of tectonic resurfacing give insight to the control of geometric features such as fault dip and spacing upon the processes and results of rotated half-graben faulting. Compared with shallowly dipping faults, steep faults require less extension to produce appreciable topographic relief .

Preliminary results that test the effect of layer thickness upon fault spacing in physical models suggest a positive correlation between model thickness and the spacing of relatively large-displacement faults that bound ridge and trough systems.

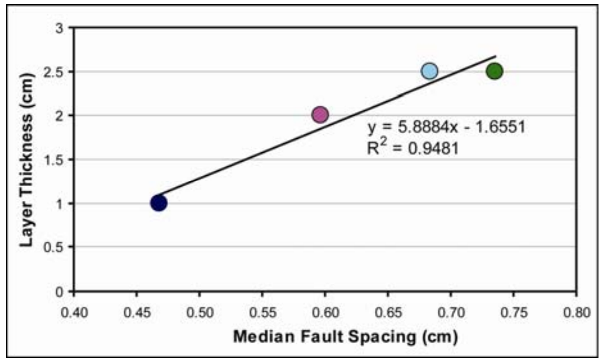


*Figure 2. Chart plotting layer thickness versus fault spacing..*

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