Formation of Grooved Terrain on Ganymede

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Abstract

The formation of Ganymede's grooved terrain, a distinct tectonically deformed surface feature that covers nearly two-thirds of the surface of this Galilean satellite, remains poorly understood. Images obtained by the Voyager and Galileo spacecrafts display that the grooved terrain on Ganymede consists of sets of periodically spaced ridges and troughs. These features are generally regarded as the result of extension of Ganymede's ice lithosphere, possibly due to global satellite expansion caused by differentiation, or melting during resonance passage. Groove sets typically have a wavelength of 3-17 km and amplitude of 200-500 km. Troughs are typically continuous for 100-1000 km and display shallow slopes of ~5°.

To better understand the formation of the grooved terrain, the extension of Ganymede's ice lithosphere is simulated using a two-dimensional finite element model, which reproduces the periodic groove structures with amplitudes reasonably consistent to the actual amplitudes observed. The model includes the effects of strain localization in effort to more realistically model the fault strength, since the previous finite element model showed that ductile necking alone is likely insufficient to reproduce the groove amplitudes observed on Ganymede. For the present model a small sinusoidal perturbation of 10 m was introduced to initiate deformation along with a strain rate of 10^{-13} s^{-1}, corresponding to 30% extension in 10^5 years. A surface temperature of 70 K was assumed such that it is consistent with the satellite's polar regions and previous models. The results from this model showed that the morphology of the surface deformation depends on the thermal gradients, which is related to the thickness of the lithosphere, and also on the rate which the ice yield strength decreases with increasing plastic strain.

References

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