Europa's Lineament History: Combining Nonsynchronous Rotation and Diurnal Stresses

Robert T. Pappalardo, Zane Crawford, Damhnait Gleeson, McCall Mullen, and John Wahr
Center for Astrobiology
Laboratory for Atmospheric and Space Research
University of Colorado
Campus Box 392
Boulder, CO 80309-0392
USA

Understanding the processes that have operated on Europa and the manner in which they may have changed through time is fundamental to understanding the satellite's geology and present-day habitability. Previous studies have shown that lineament patterns on Europa can be explained by accumulation of tensile stress from slow nonsynchronous rotation (NSR) of its ice shell, while the cycloidal planforms of other Europan lineaments can be explained if fractures propagate through a diurnally changing tensile stress field. We find that fractures propagated into combined diurnal and NSR stress fields can be "wavy" in planform for NSR stress accumulated over ~2 to 8° of ice shell rotation and average propagation speeds of ~1 to 3 m s^{-1}. The variety of Europa's observed lineament planforms from cycloidal, to wavy, to arcuate can be produced by accumulation of NSR stress relative to the diurnal stress field. The wavelength and amplitude of cycloidal and wavy lineaments increase together as NSR decreases and propagation speed increases; thus, fitting model structures to individual Europan lineaments holds promise for constraining the stress field in which the specific lineaments formed. For example, the relatively young lineament Agenor Linea, which shows a wavy planform, is a remarkable match to formation at ~1 m s^{-1} in a stress field of diurnal plus ~5° NSR. Combining NSR and diurnal stresses has implications for interpretations of Europa's evolution (steady-state vs. decreasing or episodic levels of activity), and thus its habitability through time.