SURFACE GENERATED CRACKS ON EUROPA. Sunwoong Lee, *Massachusetts Institute of Technology, Cambridge, MA 02139, USA*, Robert T. Pappalardo, *University of Colorado, Boulder, CO 80309-0392, USA*, Nicholas C. Makris, *Massachusetts Institute of Technology, Cambridge, MA 02139, USA, (makris@mit.edu)*.

Among Europa's surface features, cycloidal cracks are probably the most important for proving the existence of a subsurface liquid ocean. This is because (1) it has been shown that some of the surface cracks with cycloidal geometries can form given a number of requirements, one of the crucial ones being the presence of a subsurface ocean, and (2) ridges on the cracks are likely due to upwelling of water from a subsurface ocean through conduits formed by surface cracks (Hoppa *et al.* 1999; Pappalardo *et al.* 1999; Greenberg 2002). It has been hypothesized that surface-generate cracks due to diurnal tensile stress would reach roughly 100-m below the surface, where gravitational overburden compressive stress balances the tensile stress (Crawford and Stevenson 1988; Hoppa *et al.* 1999; Lee *et al.* 2003). These shallow cracks, however, would not provide conduits for upwelling of water since Europa's ice thickness is hypothesized to be at least several kilometers.

Based on principles from fracture mechanics, we show that surface-generated cracks induced by diurnal tensile stresses may reach the subsurface ocean if the ice shell thickness is on the order of several kilometers. It is shown that the stress intensity factor at the tip of a surface crack increases exponentially as the tip reaches near the bottom of the ice shell, negating the effect of overburden compressive pressure. The same mechanism would occur if Europa's upper brittle ice layer is mechanically decoupled from the ductile ice shell, and the cracks may penetrate through the brittle layer. These surface generated cracks may then provide paths for water or warm ductile ice to reach the surface of Europa's ice shell. This result has significant implications for astrobiology on Europa since these surface-generated cracks may provide a rapid mechanism for transport of materials from the surface to the ocean and vice-versa.

Using our ice fracture models and terrestrial ice rheology models, we estimate the strength of Europa's ice, and the propagation length and formation time of tidally driven tensile cracks. This leads to a substantial result that cycloidal cracks are likely caused by a discrete set of discontinuous smaller-scale tensile fractures. Hoppa *et al.* (1999) have shown good agreement between measured cycloid geometry and the path of a threshold tensile stress in their tidal model by fitting free parameters such as rate of crack propagation and crack initiation strength. We show that the fitted values of the crack parameters by Hoppa *et al.* (1999) are highly plausible and can be physically explained based on principles of ice fracture mechanics.

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