

STRESS, TECTONICS AND CRYOVOLCANISM. T.A. Hurford¹, ¹Planetary Geology, Geophysics and Geochemistry Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771 (Terry.A.Hurford@nasa.gov).

Introduction: Two icy satellites, Enceladus and Triton, have been observed to be volcanically active, erupting water and other materials from their surfaces. And there are hints that other icy satellites (Europa, Titan, and Pluto) have exhibited current or past periodic eruptive processes. While eruptive processes may differ on each of these bodies, for Enceladus we observe that fractures serve as a conduit for eruptive material and most icy bodies exhibit tectonic formations on their surfaces. Here we examine mechanisms, mostly tidal, that can impart stress to the surfaces of these bodies, the formation of fractures as a response to these stresses, and the ability of these fracture to serve as conduits for eruptive processes.

Stress: Stresses can be generated on the surface of planetary bodies as a result by changes in their global shapes. Thin shell approximations for these stresses have been widely used to characterize the stress induced by global deformation on a thin elastic shells driven by tidal processes, but these approximations can be used to look at other process with similar geometries. These approximations for stress best apply to thin ice shell that are decoupled from the interior by a liquid ocean layer, and aren't as good for dealing with thick viscoelastic ice shell response but still can give a feel for some qualities of the stress field.

Diurnal Stresses. Daily changes in the location of the tidal deformation due to orbital eccentricity and a body's obliquity constantly reshapes the surface and leads to diurnal sources of tidal stress. Orbital eccentricity causes the tidal bulge to migration in longitude as changes in the distance to the primary forces changes in the magnitude of the tidal deformation. And obliquity causes the tidal bulge to migrate in latitude.

Rotational Stresses. Long term changes in the rotational state also drive global scale deformation. A spin-up in rotation will result a more oblate, leading to compression in the polar regions and compression radial to the rotational axes with tension concentric to it. A spin-down will drive a more prolate shape and the exact opposite in stresses.

Stress from Orbital Migration. Long term changes in the orbital state of a body will also drive global scale deformation. Orbital recession will result in the collapse of the tidal bulge, leading to compression in the the sub/anti primary regions and compression radial to this axes with tension concentric to it. A orbital migration towards the primary will drive in increase in tidal response and the exact opposite in stresses.

Stress from Differentiation. As material in the interior of a body redistributes through the process of differentiation, there will be an effect on the tidal response of the body, which will drive global scale deformations. In general, concentration of mass towards the center of the body reduces its tidal response, which will force the tidal bulge to collapse. The resulting stresses mirror the orientation of stress from orbital recession, leading to compression in the the sub/anti primary regions and compression radial to this axes with tension concentric to it.

Tectonics: Fractures can form in response to stresses imparted to a body's surface through different stress mechanisms. In general, tensile failure is modeled as fractures that form perpendicular to tensile stresses on icy bodies. Icy satellites in the Outer Solar System exhibit fractures that have been linked to a variety of stress mechanism. For example, cycloidal ridges are though to form along fractures driven by diurnally varying stress on Europa, while fractures on Triton are consistent in orientation to stresses from a combination of inward orbital migration and spin-up.

Cryovolcanism: Different stress processes can produce varying levels of stress on the surface. While fractures are tied to the surface manifestation of stress, their ability to drive into the ice shell will ultimately be limited by the stresses produced by each mechanism and the size of the body upon which they are forming. The propagation of fractures into the ice shell can be exploited as conduits for cryovolcanic eruptions. Thus, different stress process may allow eruption of materials on the surface from varying depths in the shell.

Conclusions: As observed on Enceladus, fractures provide a conduit for cryovolcanic eruptions. The process of producing fractures on icy satellites has been well studied. And these processes can be linked to the orientation of observable fractures and the depth to which cryovolcanic material can be tapped.