approximately

$$\xi_{tidal} \sim \frac{h}{g}\frac{3GM_J a^2}{2R^3}e, \tag{1.2}$$

where ξ_{tidal} is the maximum amount Europa's surface lifts radially upward, h is the Love number relating the radial deformation of the satellite to the applied tidal potential, g is the acceleration of gravity on Europa. Given a Love number $h = 1.2$, the resulting height is approximately 30 meters. The diurnal tidal stresses exerted on the surface of Europa have approximate magnitudes of

$$\tau_{diurnal} \sim \frac{\mu l}{ag}\frac{GM_J a^2}{R^3}e,$$

where μ is the shear modulus of ice, and l is the Love number describing azimuthal deformation in response to an applied tidal potential. Using a shear modulus of $\mu = 3 \times 10^{10}$ Pa, and $l = 0.2$, the tidal stresses are approximately 30 kPa.

In addition to the daily tidal force experienced due to its eccentric orbit around Jupiter, the ice shell of Europa may be decoupled from the interior by the ocean, and could rotate differentially from its synchronously locked rocky interior. The amplitude of the non-synchronous rotation stresses is approximately

$$\tau_{NS} \sim \frac{\mu l}{ag}\frac{GM_J a^2}{2R^3}\sin(2bt), \tag{1.3}$$

where $2bt$ is the number of degrees of nonsynchronous rotation. If non-synchronous rotation stresses accumulate over 5° of rotation of the ice shell, the stresses are of order ~ 1 MPa.

1.3 Astrobiological Setting

The key to understanding whether an ecosystem can be sustained within and plausibly detected on the surfaces of icy satellites lies in understanding the geological processes which transport possible life, nutrients, and the chemical traces of life between their ice-covered oceans and surfaces. Solid-state convection is one mechanism which