3D Spherical modelling of the onset of convection within Iapetus : implications for the timing of its accretion.

G. Robuchon, G. Choblet, C. Sotin, G. Tobie

Laboratoire de Planétologie et Géodynamique, Nantes, France

The Cassini spacecraft has observed Iapetus and found two spectacular characteristics. First, the equatorial radius is about 35 km larger than the polar radius, which suggests an equilibrium shape with a 16 hours rotation period whereas the present day rotation is synchronous (79 days). Second, a mountain range about 18 km high, is perfectly aligned with the equator. In order to explain these two striking observations, Castillo et al. (2007) proposes that Iapetus froze its shape as it de-span from a rapid orbital rate of a few hours to the present synchronous rotation. Such a despinning is possible if an additional heat component was present during its early history, including short-lived radiogenic elements such as ^{26}Al, and if heat transfer is inefficient to cool down the interior (i.e. if no thermal convection starts as the satellite heat up). In this context, we performed numerical simulations of thermal convection for fluids with large viscosity contrasts in 2-D cartesian and 3-D spherical geometries, using a 3-D code named OEDIPUS (Choblet, 2005). Comparisons between 2-D and 3-D simulations allow to constrain the onset time of convection and the cooling rate of the satellite interior during the early stage. In the 3D case, gravity is depth dependent. The results emphasize the importance of taking into account not only the 3D nature of the convection pattern but also the satellite curvature . A first result is that the onset time is shorter in 3D spherical geometry than in 2D Cartesian. When convection initiates, a large number of plumes form due to the large value of the Rayleigh number and the small thickness of the thermal boundary layer. Our results suggest that convection starts if the ice viscosity gets lower than 10^{16} Pa.s, which corresponds to a temperature of 250 K for pure H_2O ice. It puts limits on the time of formation of Iapetus after the formation of CAIs.