EPSC Abstracts
Vol. 7 EPSC2012-236-4 2012
European Planetary Science Congress 2012

Effect of plasticity on the dynamics of Enceladus's south pole

M. Běhounková (1), O. Čadek (1), G. Tobie (2) and G. Choblet (2)
(1) Charles University in Prague, Faculty of Mathematics and Physics, Department of Geophysics, Czech Republic
(2) Université de Nantes, CNRS, Laboratoire de Planétologie et Géodynamique de Nantes, UMR 6112, France
(marie.behounkova@mff.cuni.cz)

Abstract

The intense activity at the south pole of Enceladus hints at an internal water reservoir. However, there is no direct evidence of liquid water at present and its long-term stability in the interior remains problematic. By modeling heat production and transfer in the ice shell in a spherical geometry, in a previous study Běhounková et al. [1], we have shown that tidal heating naturally leads to a concentration of convective hot upwellings in the south polar region, favoring the preservation of liquid water at depth. We show that large volumes of water are produced within the ice shell at the south pole during periods of elevated orbital eccentricity (3–5 times the present-day value). Strong lateral variations in the melt production and crystallization rates result in stress concentration in the south polar region, thus providing an explanation for the tectonic activity observed today. We predict that an internal ocean may be sustained over the long term as the consequence of repeated periods with elevated orbital eccentricity, leading to episodic melting and resurfacing events. In order to model the resurfacing event following a tidally-induced melting episode, we are currently incorporating plasticity effects. We also improve the modeling of tidal deformation by incorporating the Andrade model, which is expected to better reproduce the viscoelastic properties of water ice Castillo-Rogez et al. [2].

1. Model

In order to constrain the evolution of an internal liquid reservoir (with a varying width) on Enceladus and its consequences on the dynamics of the overlying ice shell, we solve simultaneously heat production by tidal friction and convective heat transfer [3]. This 3D method allows us to include consistently the effect of lateral viscosity variations on the satellite response to tidal forcing and to consider a liquid reservoir of varying horizontal extent by prescribing specific boundary conditions. Different rheology parameters have been considered in o rder to account for the uncertainties in the mechanical behavior of ice subjected to tidal forcing. Furthermore, the plasticity is introduced using a description similar to e.g. Tackley [4].

2. First results

Preliminary results using plastic rheology shows that a weak zone develops in a cold area with an annulus shape that surrounds the convecting part located at the South pole: due to the buoyant material in the hot region above the liquid reservoir a large stresses are observed in the cold region in the vicinity of the

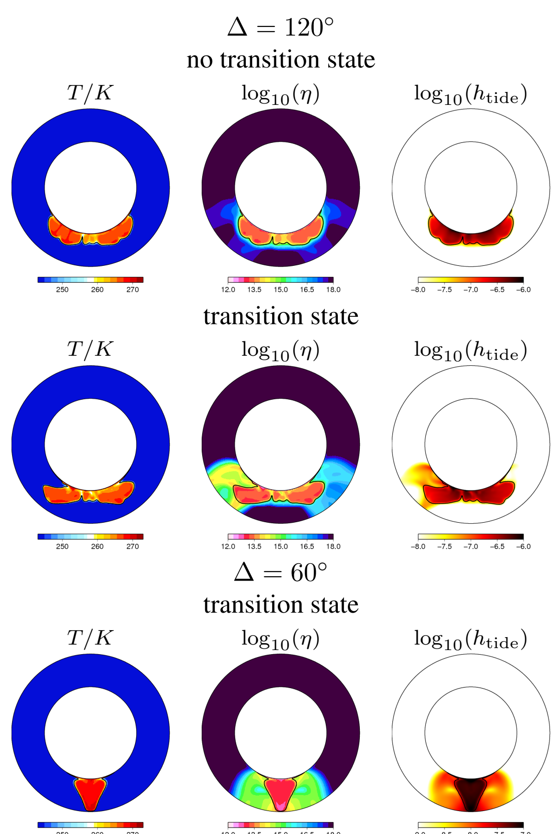

Figure 1: Illustration for the influence of the plasticity.

cold-hot transition area without plasticity. If the plastic rheology is used, this region suffers from a significant weakening (see Figure, first row). Furthermore this weakening leads to considerably larger heat transfer from the liquid reservoir near cold-hot transition area than in the case without plasticity. The crystallization rate is thus enhanced in this area. Also as expected, transition states with resurfacing events are present for the plastic rheology (see Figure, second and third rows). Nevertheless, the resurfacing is mainly observed for low latitudes in our models if the the predefined width Δ of the local liquid reservoir below the ice I shell is larger than $60°$. During the transition states, significant tidal heating is not restricted only to the hot area but to all region above the liquid reservoir (see Figure, second and third rows).

We are also currently incorporating the Andrade rheology in our model, which is challenging as we solve the viscoelastic problem in the time domain. Preliminary synthetic tests will be presented.

Acknowledgements

This work was supported by the CSF project No. P210/10/P306, MSM0021620860 of the Ministry of Education of the Czech Republic, Czech-French MOBILITY project Barrande (MEB021129). The research leading to these results has received funding from the European Research Council under the European Community's Seventh Framework Programme (FP7/2007-2013 Grant Agreement no. 259285).

References

[1] M. Běhounková, G. Tobie, G. Choblet and O. Čadek, *Icarus*, 219, 655-664, 2012.

[2] J.C. Castillo-Rogez, M. Efroimsky, V. Lainey, *J. Geophys. Res.* 116(E9), E09008 , 2011.

[3] M. Běhounková, G. Tobie, G. Choblet and O. Čadek, *J. Geophys. Res.*, 115, E09011, 2010.

[4] P. J. Tackley, *Geochem. Geophys. Geosyst., 1(8), 1026, 2000.*