EPSC Abstracts
Vol. 7 EPSC2012-520 2012
European Planetary Science Congress 2012

Titan's ice shell structure constrained from Cassini data.

A. Lefèvre (1), G. Tobie (1), G. Choblet (1), S. Le Mouélic (1), T. Cornet (1), and R-M. Baland (1)
(1) Université de Nantes, CNRS, Laboratoire de Planétologie et Géodynamique de Nantes, UMR 6112, France
(axel.lefevre@univ-nantes.fr)

Observation of Titan by Cassini have provided informations on its shape and gravity field [1, 2]. The observed shape differs significantly from the hydrostatic equilibrium shape, while the gravity field does not show significant departure form hydrostaticity. These observations imply that the topography anomalies are compensated by thickness and/or density variations. In order to assess the amplitude of these variations, we developped an interior structure model reproducing simultaneously the gravity and topography data. We compare our derived maps of ice shell thickness and density with global mapping of surface features compiled from radar, ISS and VIMS data, in order to highlight any possible correlation.

1. Methods :

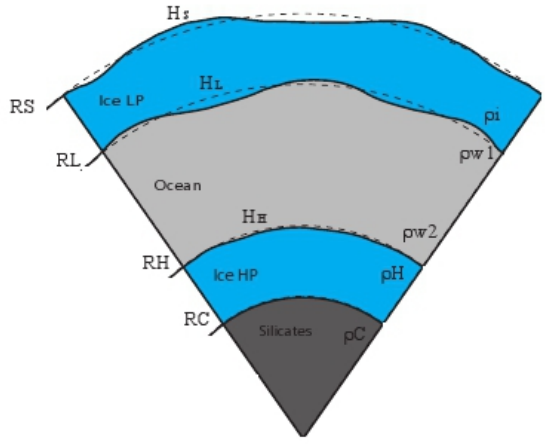

Figure 1: Titan's internal structure. With H_S, H_L, H_H, and H_C the variations respectively above the surface (R_S), the ice I base (R_L), the ocean base (R_H), and the core radius (R_C).

The interior of Titan (figure1), is assumed to be composed of a rock-dominated core, a high pressure ice, a liquid water ocean, an ice I shell [3, 4] and a crust of clathrate [5]. The position of each interface can vary laterally and these variations are determinated in order to match both gravity and topography data. The shape of each interface is determinated by the density jump across the interface and the gravitational pertubation induced by the other interfaces (external and internal). Various density contrasts and averaged layer thicknesses are considered.

Alternatively to ice shell thickness variations, Choukroun and Sotin [5] proposed that the regional negative topography at Titan's poles may be explained by subsidence associated with substitution of methane by ethane in a clathrate hydrate cap. In order to test this hypothesis, we also computed a model including a dense clathrate cap.

2. Outer shell thickness:

Figure 2 presents Titan's topography and typicals maps of ice shell thickness obtained for a set of parameters. The ice shell thickness is correlated with topography: the shell thickness is thin at the poles and thick at mid latitude. The maximum amplitude variations are of the order of 6 km. As shown in figure 2(c), the effect due to the presence of an ethane clathrate cap is not negligeable. As expected, the ice shell thickness is reduced at the poles, but the thickness observed at mid-latitude is increased. The ice shell variations can then be used to constrain the dynamical model of Titan's ice shell. For instance it may be related to the tectonic surface features.

3. Correlations with surface features

Several features on Titan surface are supposed to be possibly from endogenic origin [6, 7]. A global map-

ping of geo-morphological features on Titan is made using Synthetic Aperture Radar (SAR), Visual and Infra-red Mapping Spectrometer (VIMS) and Imaging Science System (ISS) data from the Cassini spacecraft, integrated into a GIS system. Our map of ice shell thickness will then be compared with orientation and distribution of the main geo-morphological features on the surface to analyse the possible links between endogenic and exogenic processes. Future modelling will include derivation of stress map associated with ice shell thickness variations and comparison with surface feature distribution.

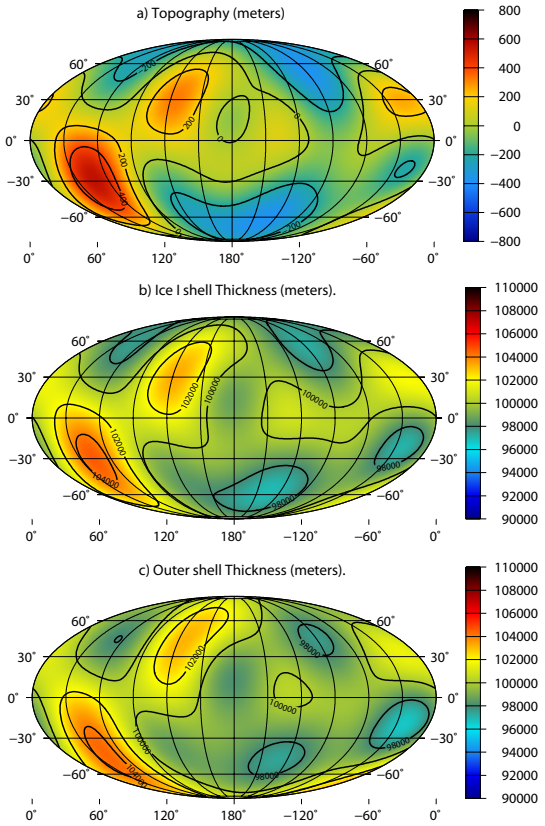

Figure 2: a) Titan's topography. b) Ice I shell tickness including surface $(H_S)$and basal (H_L) elevation variations for an average shell thickness of 100 km. c) Same parameters as b) with an additional 3 km thick polar cap of ethane clathrate. Those results were obtained for the following parameters: average thickness=100km, density jumps: clathrate/Low water ice=100 kg.m^{-3}, Low pressure ice/water =137 kg.m^{-3}, water/High pressure ice=95 kg.m^{-3}, High pressure ice/Core=1940 kg.m^{-3} .

Acknowledgements

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] Zebker, H.A., Stiles, B., Hensley, S., Lorenz, R., Kirk, R.L. and Lunine, J.I.: Size and shape of Saturn's moon Titan, Science, 324, pp. 921-923, 2009.

[2] Iess, L., Rappaport, N.J., Jacobson, R.A., Racioppa, P., Stevenson, D.J., Tortora, P., Armstrong, J.W. and Asmar, S.W.: Gravity field shape and moment of inertia of Titan, Science, 327, pp. 1367-1369, 2010.

[3] Grasset, O., Sotin, C. and Deschamps, F.: On the internal structure and dynamics of Titan, Planet. Space Sci., 48, pp. 617-636, 2000.

[4] Tobie, G., Grasset, O., Lunine, J.I., Mocquet, A. and Sotin, C.: Titan's internal structure inferred from a couple thermal-orbital model., Icarus, 175, pp. 496-502, 2005a.

[5] Choukroun, M. and Sotin, C.: Is Titan's shape caused by its meteorology and carbon cycle?, Geophy. Res. Lett, 39, L04201, 2012.

[6] Liu, Z.Y.C., Radebaugh, J., Harris, R., Christiansen, E.H., Kirk, R.L., Neish, C.D., Lorenz, R.D., Stofan, E.R. and the Cassini Radar Team: Evidence for endogenic origin of mountains on Titan, LPSC 43^{rd}, 2012.

[7] Radebaugh, J., Lorenz, R.D., Kirk, R.L., Lunine, J.I., Stofan, E.R., Lopes, M.C., Wall, S.D. and the Cassini Radar Team: Mountains on Titan observed by Cassini Radar, Icarus, 192, pp. 77-91, 2007.