CLUES ON TITAN'S INTERNAL STRUCTURE FROM CASSINI-HUYGENS MISSION.

J. Castillo,[1,2], N. Rappaport[1], A. Mocquet[2] and C. Sotin[2], [1] Jet Propulsion Laboratory NASA, Pasadena, CA, USA, e-mail: Nicole.J.Rappaport@jpl.nasa.gov, [2] Laboratoire de Planétologie et Géodynamique UMR-CNRS 6112, Nantes, France, e-mail: castillo@chimie.univ-nantes.fr.

Introduction: Titan, Saturn's largest satellite, will be under the focus of the Cassini-Huygens mission by 2004. Four flybys will be dedicated to the measurement of the satellite's gravity potential. This presentation aims toward estimating which features of Titan's internal structure can be derived from these measurements. To this end, we compute the tidal response of Titan as a function of internal structure modelling.

Methods: *Computation of tidal response* We compute periodic Love number k_2 which can be directly derived from observable data, specifically the dynamic part of the gravity coefficients of the quadrupole moment of the satellite [1]. This parameter is computed using the method described in [2], which considers that large icy satellites behave like Maxwell bodies.

Modeling of the internal structure: In absence of constraints other than mean density and radius, internal structure models are built from numerical models of geodynamics and thermal evolution. *Lunine* (1993) [3] remarked that known constraints such as ground-based radar and spectrometric observations are explained only if a deep ocean exists inside Titan. Results from [4] show that an internal ocean may be present, provided that at least 5% NH_3 is mixed with water, thus decreasing the freezing temperature of the liquid. Nevertheless, in the absence of further geophysical constraints, models with and without a deep ocean are considered.

Models illustrated in Figure 1 are based on modelling of Titan dynamics and thermal evolution of [4]. Parameters investigated are: the radius and density of a possible iron core, the density of the ocean, the structure of the icy crust and of the high-pressure layer. Density of the silicate mantle is adapted so that the model's mean density corresponds to the available constraints. This density remains inside the relevant domain of values inferred from chondrites (ranging from 3 to 4.4) [e.g. 5].

Thermal profiles in icy layers are computed after considering all heat sources, especially radiogenic heating and tidal dissipation. Global tidal dissipation is inferred from the complex part of k_2, as shown in equation 21 of [6]. A simple convective model is considered, since exact thickness of the lithosphere happens to have little influence on the gravity potential. Elastic moduli of the layers of ice are drawn from [7]. The corresponding parameters for silicates and iron come from reference Earth model PREM [8]. Viscosity in the silicate is supposed to correspond to the one encountered in Earth's upper mantle.

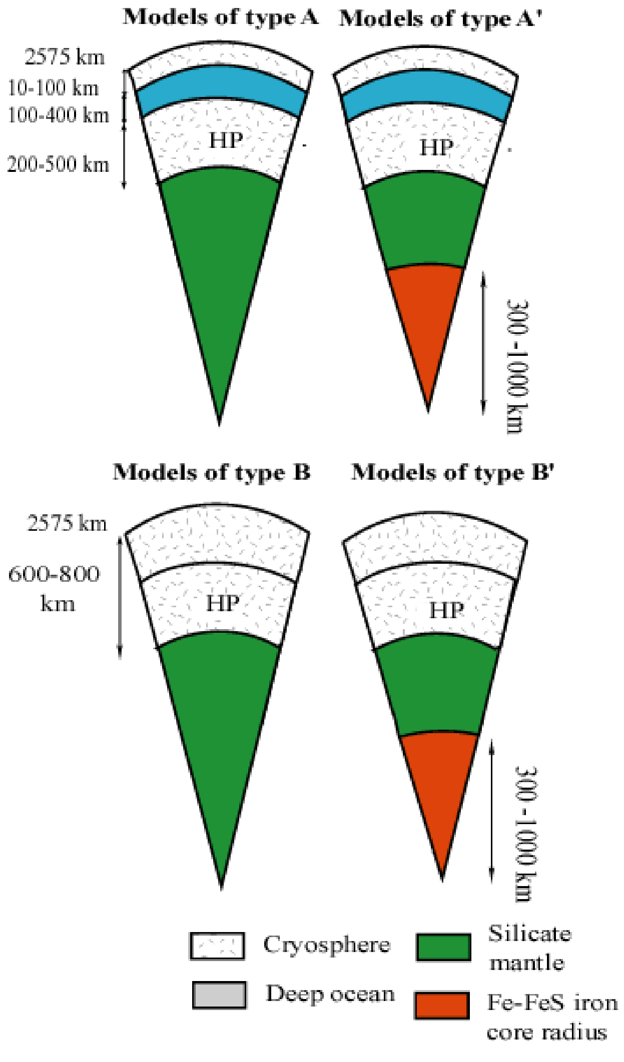
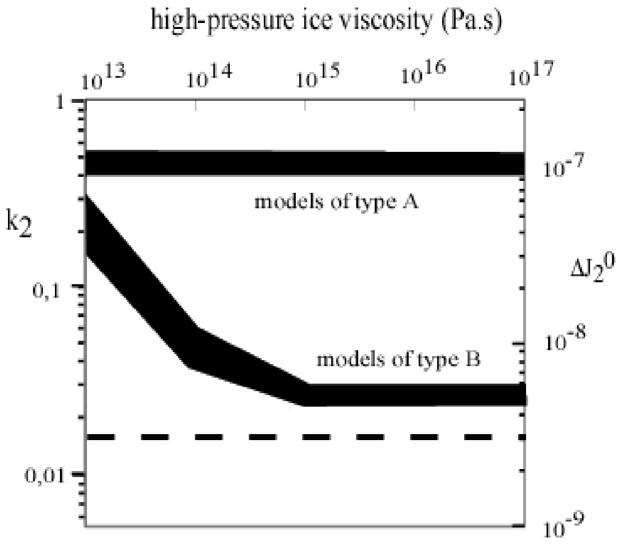


Figure 1 Models investigated in this study. Arrows indicate variation range of layers thickness. HP refers to high-pressure ices.

Results: Values of k_2 are gathered in Figure 2, as a function of viscosity in the high-pressure icy layer. These results distribute in three domains : first, values for models with and without a deep ocean are distinguished by a factor 20. This is a consequence of the decoupling effect of the presence of an ocean. In models with no deep ocean, the cryosphere tends to act in the same way when the viscosity of the ices is lower than 10^{15} Pa.s. As a result, such models display a gravity signature similar to the one of models with an ocean. Inside each region, variations are mainly due to the influence of the ocean density for models with a deep ocean and iron core thickness for models with no ocean, except when ice viscosities of the ices are lower than 10^{15} Pa.s. In the latter case, k_2 is mainly governed by the total thickness of the cryosphere.

The use of very stable coherent signals in the X and Ka bands will allow us to expect an excellent determination of gravity coefficients, with absolute accuracy between 10^{-8} and 10^{-9} [2]. As a consequence, it will be possible to highlight the presence of a deep ocean inside Titan. Gravity data ranging from 6.10^{-9} to 10^{-8} will provide evidence for the absence of a deep ocean but low viscosity in the ice. As shown by [1], the signature of the icy crust is better expressed in the equatorial bulge and then retrieved from altimetric measurements, through Love number h_2. It will be then quite impossible to draw information about this region from Cassini-Huygens gravity measurements. Nevertheless, the influence of this region will create supplementary inaccuracy on the derivation of other features. For example, core radius will be known only to within 150 km. Complementary observations such as detection of a magnetic field or dimensionless moment of inertia, will help getting better information on this region.

Conclusion: Inversion of k_2 from gravity measurements by Cassini-Huygens could allow us to detect a deep ocean inside Titan. Nevertheless further numerical modeling is necessary to indicate if viscosity in the ice pressure layer can be lower than 10^{14} Pa.s in models with no deep ocean. The inversion of k_2 from gravity coefficients also requires fine assessment of the parameters involved in the dynamic part of ΔJ_2 such as orbital parameters and true anomaly (see equation 15 of [2]). Error on these parameters must be lower than 5% to recover k_2 with an accuracy to within 10^{-3}, and get information about the core radius and ocean density. Furthermore, it will be necessary to take into account tidal phase lag which can reach several tens of degrees for models with no deep ocean.



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