FORMATION AND EVOLUTION OF AN INTERNAL WATER OCEAN ON TITAN. G. Tobie[1], O. Bollengier[1], A. Lefevre[1], N. Marounina[1], J. Monteux[1], R.-M. Baland[1], L. Bezacier[2], H. Amit[1], S. Carpy[1], G. Choblet[1], and O. Grasset[1]. [1]Université de Nantes, CNRS, Laboratoire de Planétologie et Géodynamique de Nantes, UMR-6112, 44322 Nantes, France; [2]European Synchrotron Radiation Facility, 38000 Grenoble, France; (gabriel.tobie@univ-nantes.fr).

For many years, a variety of theoretical models have predicted the presence of a liquid water ocean inside Titan. Several lines of evidences (tides [1], rotation [2,3], electric field perturbations [4]) now confirm that Titan harbors a water ocean (possibly salt-rich [2,5]) underneath an outer icy shell several tens to more than hundred kilometers thick. Analyses of the gravity and long-wavelength topography data indicate that the thickness of the ice shell is estimated to vary by about 5 km, which may be the consequence of heterogeneous ocean crystallization processes [5,6,7,8]. Moreover, the detection of a significant amount of ^{40}Ar (the decay product of ^{40}K) in Titan's atmosphere ([9]) indicates that leaching processes permitted the extraction of a significant amount of potassium from the rocky core to the ocean ([10]), followed by the outgassing of ^{40}Ar through the outer ice shell [11].

Despite the major advances provided by the Cassin-Huygens mission, the physical and chemical characteristics of the present-day internal ocean remain uncertain as well as its past evolution. The ocean probably played a crucial role in the formation of the primitive atmosphere as well as in the chemical exchanges between the inner part and the atmosphere all along Titan's evolution. In order to address the conditions under which the ocean formed and evolved throughout Titan's history, we combine different numerical and experimental approaches.

To constrain the ice melting during the accretion stage and the formation of a surficial ocean, we developed a new 3D numerical model which simulates the cumulative effect of large impacts ([12]). Our simulations show that the formation of a surficial ocean may start very early during the accretion stage, when the radius of the growing moon exceeds only 1200-1500 km. At the end of the accretion, the liquid water on Titan may constitute up to 30-35% of the total mass and should be in equilibrium with a very massive atmosphere [11]. In order to determine the post-accretional cooling and crystallization of the primordial ocean, we are currently developping a model describing the coupled thermo-chemical evolution of the ocean-atmosphere system.

Once separated from the atmosphere by the solidification of a primordial crust, the evolution of the ocean is mostly controlled by heat and mass transfers with the inner core and throughout the outer icy shell. To constrain the chemical evolution during the differentiation of the inner proto-core and the ocean crystallization, we conducted a series of experimental investigations at high pressure with particular focuses on two water-gas systems: H_2O-CO_2 ([13]) and H_2O-CH_4 ([14]), which are the dominant carbon species in Titan's interior ([15]). Based on these new experimental results, we are developing a thermodynamical model which will allow us to compute the time evolution of CH_4 and CO_2 content in the ocean during crystallization and the exchange rate from the inner core to the surface.

Finally, a last crucial aspect concerns the description of the ocean crystallization and the treatment of the heat transfer throughout the entire H_2O mantles (inclucing solid and liquid layers). By combining numerical models describing the dynamics of the water ocean and the ice shells (low-pressure outer ice layer and high-pressure inner ice layer), we quantify the crystallization rate of the ocean and compare the modeled structure to the available gravity and topography data ([8]). The main objective of this work is to provide theoretical constraints on the possible evolutionary path followed by the internal ocean since its formation.

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