STRUCTURE OF THE UPPER ICE MANTLE OF TRITON. J. Ruiz[1] and A. Torices[2], [1]Departamento de Geodinámica, Universidad Complutense de Madrid, 28040 Madrid, Spain, jaruiz@eucmax.sim.ucm.es. [2]Facultad de Ciencias Geológicas, Universidad Complutense de Madrid, 28040 Madrid, Spain.

Introduction: Triton's images, obtained by Voyager 2 spacecraft in 1989, showed that this Neptune's satellite have a relatively young surface, of maybe ~1 Gyr [1]. Recent analysis of impact craters abundance and size suggests a lower age; ~100 Myr if the impactors come from Kuiper Belt [2]; lesser than 10 Myr, if the asymmetry in craters distribution between hemispheres, as indicative of cratering which has been caused exclusively by a planetocentric population of objects, is taken into account [3]. Therefore, it seems probable that Triton is geologically active at present, and even could have an internal ocean [2,4]; the materials, resposible of the surface renovation, would come from it.

This cryovolcanic activity is in accordance with the presence of surface structures that have been interpreted as calderas, cryoclastic deposits, flows, etc [1,5]. This activity would include different types and combinations of explosive and effusive eruptions, and assuming the morphologic similarity between terrestrian volcanic structures and Triton's, it has been suggested that they have been formed by similar physical processes, in connection with comparable physical properties which would control the morphology and behaviour of eruptions [5]. It has been suggested that the likely eutectoid cryomagma composition, which is present in Triton could correspond to ammonia-water, ammonia water-methanol, or ammonia-water-non polar gas series [6]. Geomorphologic similarity between them can arise partly from a rheologic similarity between ammonia-water-methanol series and silicate series ranging from basalt to dacite [6].

From estimates of the bulk composition of Triton and the preservation of topography, the most abundant and likely cryomagma component is H_2O [5]. Other surface components, that are present, are CH_4, N_2, CO, y CO_2 [7]. Even Triton`s crust is covered by nitrogen and other volatiles-rich-frost, is probably that the dominant component is H_2O because the rest of components, mentioned above, are non polar or weakly polar molecular liquids which without water can not formed rigid solids stable against sublimation or melting [6].

In this work, we analyse the relation between pressure and temperature in the conductive part of Triton`s ice layer, its consequences in relation to structure of the upper part of ice mantle, the possible existence of an internal ocean and the maintenance of magmatic activity until present.

Method: It is assumed that Triton is differenciated in a thick ice layer and a rock and metal core [1,8]. If there are different substances to water ice in the ice layer, it is considered that they don not affect to density and thermal conductivity. For the calculation of pressure in depth, it is assumed a constant ice I and ice II density: 940 kg m^{-3} and 1180 kg m^{-3} respectively. Triton's mass and radius are taken as in [9].

In conductive regime, the variation of temperatures in function of radius, r, can be described from Fourier's law, $dT = -(F_r / k)\, dr$, where F_r is the heat flow in r, and k is the thermal conductivity. If we consider a spherical ice layer, heated from below (from radiogenic heating in the core), in energetic equilibrium situation, $F_r = F R^2 / r^2$, where F is the surface heat flow, and R is the body radius. In this work, a F value of 3,3 mW m^{-2} is adopted [10], which corresponds to a chondritic core composition. k is a function of temperature; here the relation $k = k_0 / T$ will be used, where k_0 is a constant. If we replace both functions in the Fourier's law, the temperature profile is obtained by integration from R until r,

$$T_r = T_R \exp\left[R F (R / r - 1) / k_0 \right] . \qquad (1)$$

For ice I k_0 = 567 W m^{-1} [11]. For ice II k_0 = 420 W m^{-1} is taken, value that adjust properly the thermal conductivity given in [12]. Finally, the boundary between ice I and ice II stability fields is described by

$$P_{I\text{–}II}\ (\mathrm{MPa}) = 0.92\, T\,(\mathrm{K}) - 6.26\ , \qquad (2)$$

[13], where P_{I-II} is the boundary pressure for T.

Possibility of an internal ocean: The radiogenic heating, seems enough to raise, in deep interior, the ice temperature over ~176 K that correspond to the beginning of melting in the ammonia water system, or over ~153 K that is the beginning of melting in ammonia-water-methanol system, and therefore, if ammonia is certain importance mantle component, an internal ocean of eutectoid composition could exist, or at least a significant melting grade [9]. But on the other hand, due to dependence of the thermal conductivity of Ice I from temperature, Triton's ice mantle could be dominated by ice II [14]. The ammonia-water melt would float easyly in ice II, and should be found frozen on the phase transition level between ice I and ice II (due to be some denser than water ice I) [14].

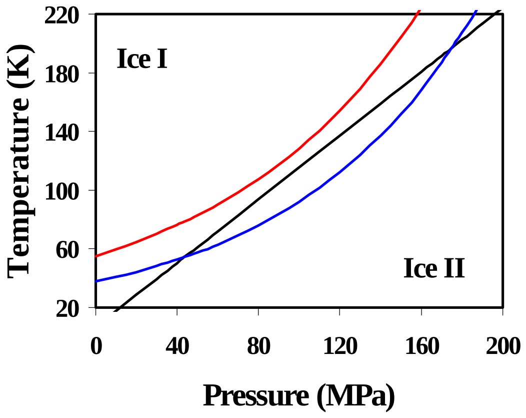

Figure 1. *P-T* curves for *Ts* values of 38 K (blue) and 55 K (red). Convection is not considered in the draw.

To have an internal ocean that is stable at present against freezing, it looks necessary that low heat conductivity surface ices raise the effective temperature on surface [9]. In this sense, we find that if we start from a surface temperature of 38 K, an ice I layer would experience transition to ice II at ~60 km under surface, and at ~54 K of temperature. For surface effective temperatures of ~50 K, the pressure-temperature curve (*P-T*) in the conductive ice don not cut any more the phase transition between ice I and II. Ice II could be present in the deepest part of mantle only, and under ice I in convection (with temperature that should allow melting in presence of ammonia).

***P-T* curve in a conductive water ice II mantle:** If effective surface temperature is lesser than ~50 K, transition from ice I to ice II should be produced to relatively little depth. We have analyzed the relation between pressure and temperature in the conductive ice II under the external ice I layer. Ice II thermal conductivity is approximately ¾ of ice I thermal conductivity, therefore, the elevation of temperature with depth is greater. It leads to a paradoxical situation. The *P-T* curve cut again the phase transition between ice II and ice I. It happens to a greater depth and temperature how much minor is *Ts*. For *Ts* = 38 K, the phase transition would be reached at ~190 km of depth and ~196 K of temperature. In medium size satellites, like Rhea, it has been suggested that *P-T* curve, once that reach the boundary between stability fields of ice I and ice II, would be placed on phases limit, due to the change in thermal conductivity [15]. But in the case of Triton, its much greater mass don not allow this possibility.

One might ask what real sense this situation has, because it results gravitationally unstable. At first, it could be avoid if ice II were in convection at lesser depth and temperature than transition from ice II to ice I. But even so, if we start from a Triton`s interior, which is enough hot so that the ice II only can exist under ice I in convection, from (1) and (2) it can be infered that with the cooling of the satellite, the ice II phase would begin to grow between conductive ice I. On the other hand, it has been pointed out that certain features, interpreted as having a volcanic origin (as linear y rugged ridges) could have been formed in relation with mantle's plumes [5]. If it is right, these mantle's plumes could have its origin in the mentioned instability, though this possibility must be considered with caution.

Conclussions: The presence or absence of low thermal conductivity ices on surface or near it, has a decisive importance in the understanding of internal structure and the maintenance of geological activity in Triton. If these ices have the effect of elevating effective surface temperature in a dozen of degrees ,or more, the interior would be enough hot to allow the existence of an internal ocean. If, on the contrary, effective surface temperature is not elevated significantly, then, the internal structure could evolve to a unstable gravitationally situation.

One future work line consists of modeling the cooling of an ice I mantle in Triton, and the possible growth of ice II in the interior of ice I, to investigate if the associate instability can make some role in the maintenance of geological activity and the surface renovation.

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