Compaction-driven evolution of Pluto's rocky core: Implications for water-rock interactions.

Leila Gabasova[1], Gabriel Tobie[2] and Gaël Choblet[2], [1]IPAG, University of Grenoble, France (leila.gabasova@univ-grenoble-alpes.fr) and [2]LPG, University of Nantes, France

Introduction: Indirect evidence suggests that Pluto possesses an internal ocean [1]. In order to assess the evolution of this ocean and its interaction with the rocky core, we revisit the thermal evolution of Pluto's interior by modeling the porosity evolution of the core and by parameterizing the effect of porous circulation on heat transfer. Exploring various initial conditions and rheological properties of the core allows us to determine the evolution of the porous layer, the vigor of water-rock interactions and the consequences for core cooling. We also examine the effect of core evolution on the persistence of a liquid ocean beneath the ice mantle.

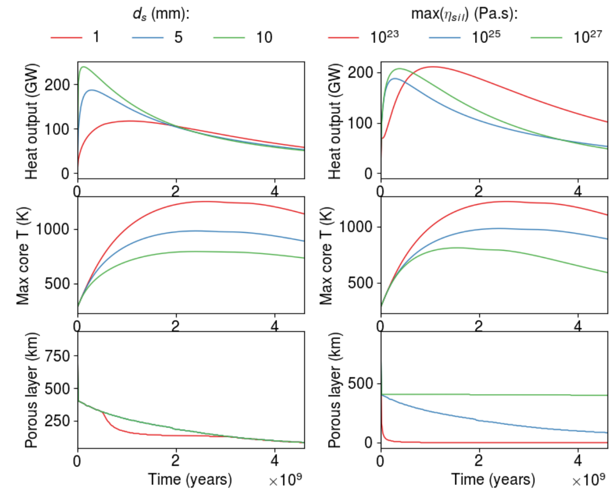
Model: To model core compaction, we use a unified nonlinear viscoelastoplastic compaction model for saturated porous materials as defined by [2]. The model describes the possible range of the material's rheological responses to stress, from linear viscoelastic deformation, going through intermediate viscoplastic cases, to full plastic compaction, and presents a set of incremental porosity evolution equations for these cases. We then parameterize the fluid convection within the porous layer of the core as an effective thermal conductivity. The core evolution model is coupled with a pre-existing ice mantle evolution model [3] which assumes a stagnant lid regime.

The principal model parameters are the core grain size d_s, the maximal silicate viscosity threshold $\max(\eta_{sil})$, initial porosity φ_0 and initial ammonia concentration in the ocean $[NH_3]_0$.

Results: Fig. 1 shows a sample of the effect of different core parameters on its evolution, Fig. 2 shows the same for the liquid ocean, and Fig. 3 shows a temporal cross-section of the ice mantle for the nominal model parameters ($d_s = 5$ mm, $\varphi_0 = 0.2$, $\max(\eta_{sil}) = 10^{25}$ Pa.s, $[NH_3]_0 = 1\%$). More in-depth results will be presented at the meeting.

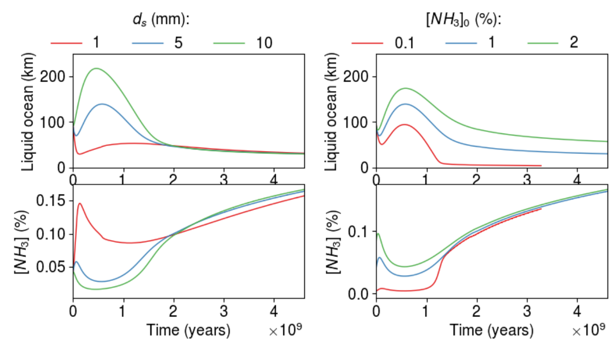
Discussion: This is the first model for Pluto to feature compaction and hydrothermal circulation in the core, providing key constraints on the vigor of water-rock interactions through time. A general outcome of our simulations is that the core can retain a thick porous outer layer through the first 100 My, stimulating intense water-rock interactions, and a liquid ocean persists until the present day in most cases. This model can be applied to other small icy Solar System bodies, which we will demonstrate for Charon.

References: **[1]** F. Nimmo et al. *Nature*, 540(7631):94, 2016. **[2]** V. M. Yarushina and Y. Y. Podladchikov. *J Geophys Res Solid Earth*, 120(6):4146–4170, 2015. **[3]** G. Tobie et al. *Nature*, 440(7080):61–64, 2006.



(a) Grain size (b) Maximal silicate viscosity

Figure 1: Effect of parameter variation on core evolution



(a) Grain size (b) Initial NH_3 concentration

Figure 2: Effect of parameter variation on ocean evolution

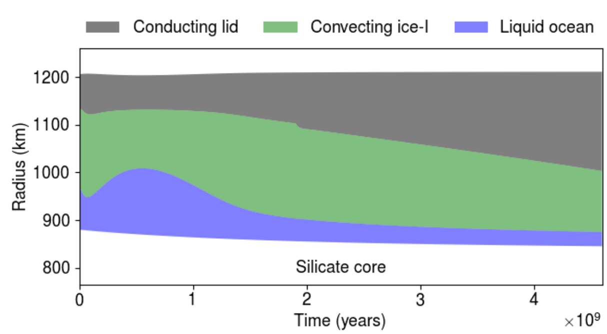


Figure 3: Mantle evolution for nominal model case