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EFFECTS OF IMPACTS ON THE CRYSTALLISATION OF PLANETESIMALS IN FORMATION IN THE EDGEWORTH-KUIPER BELT

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Abstract. Kuiper Belt objects are among the most primordial objects of the outer solar system. While their present-day composition is expected to be similar to that of primordial planetesimals produced in the outer solar nebula, it could have been substantially modified by the heating induced by high collision rates in the early Edgeworth-Kuiper Belt. To examine the effects of impact on the crystallisation of planetesimals, we use a cometary nucleus model derived from Espinasse et al. (1991), accounting for collisional energy input, "a-la" Orosei et al. (2001). The results show following the mass fraction dust/ice ratio that effects of impact are more or less efficient.

1 Introduction

Our 1D model of cometary nucleus solves the heat conduction and gas diffusion equations in a porous body assumed to be spherically symmetric. The first model of nucleus is made of H_2O ice and the second of a mixture of H_2O ice+dust. Ice can sublimate and release the gas within the porous matrix. The dust is represented according to the formalism proposed by Espinasse et al. (1993). The ice of the nucleus is initially amorphous and we simulate one collision 10 years after the beginning of the simulation. In order to evaluate the influence of dust on the crystallisation of the nucleus, we consider 3 values of the mass fraction dust/ice ratio: $f = 0$, 1 and 10.

2 Impact Modeling

To simulate collisions on the nucleus, we add a fraction of the kinetic energy induced by the projectile in the form of heat in the interior of the body on severals meters depth. The propagation of the impact heat is described following the approach of Orosei et al. (2001). The distribution of impact heat results in a homogeneous energy density deposited in the subsurface within a cylinder the cross-section and depth of which correspond respectively to the half size of the projectile. For the collision, we consider only the increase of temperature of the subsurface, and neglect any ablation.

The fraction of kinetic energy of the impactor that could be transfered in the form of heat to the nucleus is relatively unknown and we adopt a intermediate value of 50% for a velocity of the impactor equal at 1 km/s.To minimize computation time and the effects of collision, we used an arbitrary small target of 1 km radius and an impactor of 100m radius only. The orbital parameters are those of Quaoar. The others thermodynamic parameters are typical values for TNOs.

3 Results

Figures 1 and 2 show a decrease of the crystallisation depth when the fraction dust/ice increases. With a mass fraction f of 10, the layers of the nucleus are never fully crystallised. We note that the role of conductivity of ice is important: when the ice is amorphous, the conductivity is constant and increases with the fraction of dust/ice. When the ice is crystalline, the conductivity depends on temperature. At low temperature, the conductivity decreases when the fraction dust/ice increases. When the nucleus is purely made of amorphous H_2O ice the

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outwards diffusion of the layer's energy is very low due to its reduced conductivity. The accumulation of energy in the amorphous layer implies a progressive crystallisation. The efficiency of this conversion process speeds up since it is exothermic. When the dust is present, the conductivity is more important and the crystallisation timescale is longer than the energy diffusion timescale hence preventing the ice to reach crystallisation temperature.

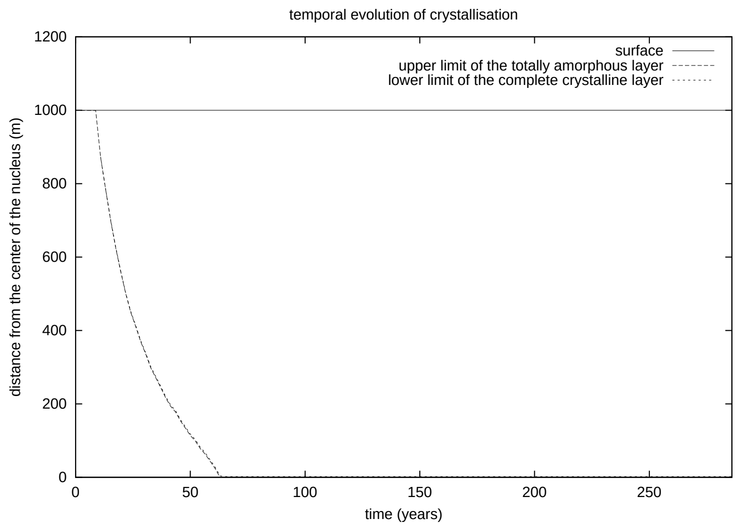

Fig. 1. nucleus 1: f=0

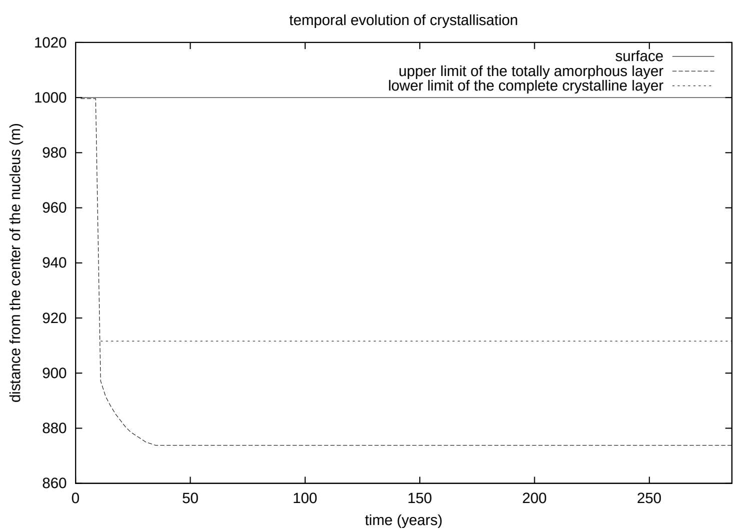

Fig. 2. nucleus 2: f=1

References

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