Modification of cometary interiors by early thermal evolution and collisions

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In the early solar system radiogenic heating by $^{26}$Al and collisions are the two prominent ways expected to modify the internal composition of cometary interiors, building blocks of comets, by removing highly volatile compounds like CO, CO$_2$, and NH$_3$. However, observations indicate that even large comets like Hale-Bopp (R $\approx$ 70 km) can be rich in these highly volatile compounds [1]. Here we constrain under which conditions cometary interiors experiencing both internal heating and collisions can retain pristine interiors. For this purpose, we employ both the state-of-the-art finite-difference marker-in-cell code I2ELVIS [2] to model the thermal evolution in 2D infinite cylinder geometry and a 3D SPH code [3] to study the interior heating caused by collisions among cometary objects. For simplicity we assume circular porous cometary objects with a low density ($\approx$ 470 kg/m$^3$) based on measurements for comet 67P/Churyumov-Gerasimenko [4].

For the parameter study of the thermal history we vary (i) cometesimal radii, (ii) formation time and the (iii) the silicate/ice ratio. For the latter we keep the mean density fixed and change the porosity of the cometesimal. For the impact models we use porous, low-strength objects and vary (i) target and (ii) projectile radii, (iii) impact velocity as well as (iv) impact angle. Potential losses of volatile compounds from their interiors are calculated based on their critical temperatures taken from literature [5]. Our combined results indicate that only small or late-formed cometary interiors remain mostly pristine, while early formed objects can even reach temperatures high enough to melt the water ice.

REFERENCES
