A Cometary Nucleus Model Taking Into Account all Phases of Water Ice: Amorphous, Crystalline and Clathrate.

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Introduction: Comets are currently supposed to be the most primitive objects in the solar system. Their chemical composition suggests that cometary material is formed at low temperature in cold regions of the solar nebula or in the ISM, where volatile molecules can condense.

The chemical composition and water ice structure included in comets are mainly affected by temperature and molecular composition of the surrounding environment during both 1) the formation of cometary materials in the cooling solar nebula or ISM and 2) the thermodynamical evolution of comets in the solar system.

Current theories [1], models of cometary nuclei [2-3] and of ice formation in the protoplanetary disk [4-5], and laboratory studies [6-8] suggest that cometary materials could be formed of pure crystalline water ice, amorphous water ice, clathrate hydrate, or a mixture of these structures of ice, i.e. of icy grains, depending on the location of formation of both the cometary material (in ISM or cooling solar nebula) and the comet in the solar system [9], and the thermodynamical evolution of comets since their formation[10].

Here, we present a 1D model of comet, which takes into account all structures of water ice and phase changes during its thermal evolution around the sun.

The model of cometary nucleus: This model considers a sphere composed of a porous predefined mixture of water ice, volatile molecules (in gas and solid states) and dust grains in specified proportions.

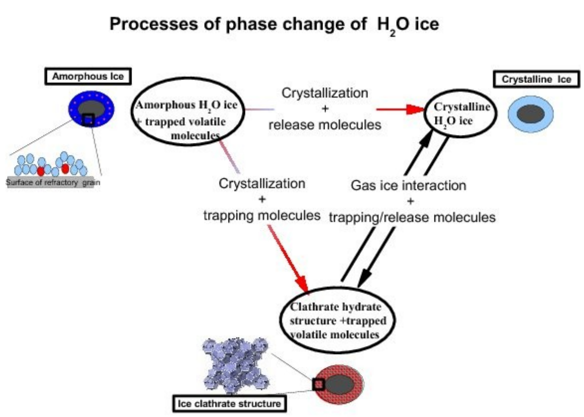

Figure 1:Schematic view of the main physical processes taken into account in the model.

All initial water ice structures (amorphous, pure crystalline, clathrate hydrates or a mixture of these three structures) can be taken into account following assumptions on the place of formation of the cometary materials and comets. This model describes heat transmission, latent heat exchanges, sublimation/condensation of volatile molecules in the nucleus, gas diffusion, gas release and trapping by crystallization and/or clathrate formation/dissociation processes, gas and dust release and mantle formation at the surface, as well as water ices (see figure 1) transitions (amorphous-to-pure crystalline, amorphous-to-clathrate hydrates and pure crystalline-to-clathrate hydrates and vice-versa) following the initial physical assumptions considered and the thermodynamical evolution of the comet in solar system.

Results: This model allows us to predict different outgassing profiles of volatile molecules depending on the water ice structure and distribution of volatile molecules between the “trapped” and “condensed” states in the icy matrix. We pretend that this model will be able to interpret the outgassing observations that will be recorded by the Rosetta mission and to constrain the chemical composition and the water ice structure in the interior of the target 67P/Churyumov Gerasimenko comet.

Acknowledgements: This work has been supported by the French "Centre National d'Etudes Spatiales" (CNES).

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