THERMAL EVOLUTION AND PHYSICAL DIFFERENTIATION OF SHORT PERIOD COMETS. Espinasse S., Coradini A., Federico C., and Capaccioni F., Istituto di Astrofisica Spaziale, Reparto Planetologia, Viale dell'Università, 11. 00 185 ROMA-ITALY.

The purpose of this work is to study the evolution of the subsurface layers of a short period comet. Particular attention is given to the variations of porosity and changes of composition of the superficial layers due to sublimation - recondensation phenomena and to gas diffusion processes through the pore system.

Our first nucleus model is composed of a water ice and dust mixture in specified proportions (see Table 1). This matrix is assumed to be porous ; in fact, one of the important findings of the recent observations of Halley's comet was the measurement of an average density of the nucleus as low as 280. to 650 kg/m3 (1). The ice fraction is initially crystalline. We did not consider the case of an initially amorphous state of the ice fraction because the subsurface layers of a short period comet crystallize very early (2).

The model is based on the resolution of two symmetric diffusion equations through the whole nucleus, one describing the transport of matter and the other the transport of heat. These equations are linked by the source term which accounts for production or loss of gas in terms of matter or of latent heat.

The heat conduction coefficient of the cometary material is obtained from that of compact crystalline ice, silicate rock and radiative transfers from the pore walls.

The source term accounts for the exchanges of latent heat due to sublimation - recondensation phenomena under two assumptions. First, we assume that the water vapor present in the pore system acts as a perfect gas. Second, we consider that sublimation and recondensation are instantaneous in order to maintain locally the thermodynamic equilibrium between the solid phase and its vapor. Under these assumptions, the source term depends on the variation of the pressure due to vapor diffusion and on the variation of the saturation pressure of the vapor due to the evolution of the temperature.

To determine the gas conduction coefficient, the pore network is considered as a system of cylindrical pipes. The diffusion regime depends on the mean free path of the molecules of gas and it is that of Knudsen, or viscous.

The diffusion equations are solved numerically, using spherical coordinates and assuming spherical symmetry for the nucleus. The finite difference method chosen is that of Douglas-Jones (3).

The initial conditions chosen for calculations were 100 K for the temperature and the corrisponding saturation pressure for the vapor pressure. The results obtained with this model are summarized in Table 1. They describe the evolution of the porosity and of the thickness of the dust mantle developed at the surface of the comet nucleus on the

© Lunar and Planetary Institute • Provided by the NASA Astrophysics Data System

orbit of P/Dutoit-Hartley.

This is the first step of this study and we are aware that it is very unrealistic. The model is being improved as follows :
- CO_2 has been added in the icy matrix.
- the possibility is given to the dust particles to be ejected from the surface of the nucleus according to the force balance between gases fluxes, gravity and centrifugal forces and to the dust particles size distribution.

At each time step and for each layer, depending on the sublimation - recondensation phenomena and on the remaining dust particles in the subsurface layers, the physical properties (density, porosity, composition) and the thermodynamical properties (heat conductivity coefficient, heat capacity) for each layer are adequately modified.

The calculations will be performed for a nucleus on the orbit of P/Dutoit-Hartley because it is one of the possible targets for the Rosetta/CNSR mission. Different nucleus compositions with different CO_2/H_2O ice ratios and different dust/ice ratios will be investigated. Results will be presented on the evolution of the stratigraphy of the nucleus and of the production rates of CO_2, H_2O and dust particles as a function of the heliocentric distance. Several phenomena have already been evidenced, such as the depletion of CO_2 ice in the subsurface layers and the possible presence of a dust layer at the nucleus surface.

Table 1 :

Initial conditions	Mantle thickness after 20 revolutions	Mantle porosity
Porosity:80%		
Dust/Ice:0.5	16 cm	97.7%
Dust/Ice:0.75	18 cm	96.7%
Porosity:50%		
Dust/Ice:0.5	9.5 cm	94.2%
Dust/Ice:0.75	10.5 cm	91.8%

References : (1) Rickman H., 1989. Adv. Space Res. 9,(3)59-(3)71.(2) Espinasse S., Klinger J., Ritz C., and Schmitt B., 1989. ESA SP-302, 185-190. (3) Remson I., Hornberger G.M., and Molz F.J., 1971.

© Lunar and Planetary Institute • Provided by the NASA Astrophysics Data System