

THE LOSS AND DEPTH OF CO₂ ICE IN COMET NUCLEI

F. P. Fanale and J. R. Salvail, Planetary Geosciences Div., Hawaii Inst. of Geophysics, Univ. of Hawaii, Honolulu, HI.

An analytical model has been developed to simulate the material differentiation of a cometary nucleus composed of water ice, putative unclathrated CO₂ ice and silicate dust in specified proportions. Selective sublimation of any free CO₂ ice present in a new comet would produce a surface layer of water ice and dust overlying the original CO₂ rich material. This surface layer reduces the temperature of buried CO₂ ice and restricts the outflow of gaseous CO₂. On each orbit, water sublimation at smaller heliocentric distances temporarily reduces the thickness of the water ice and dust layer and liberates dust. Most of the dust is blown off the nucleus, but a small amount of residual dust remains on the surface. (cf. Houppis et al., 1985) Our model includes the effects of nucleus rotation, arbitrary orientation of the rotation axis, latitude, heat conduction into the deep interior of the nucleus and restriction of CO₂ gas outflow by the water ice and dust layer, features that were not included in the Houppis et al. model. Specifically, we investigate the effects of the permeability of the surface water ice layer, the nucleus rotation rate and the latitude. The loss rate of CO₂ and the resultant depth of CO₂ ice are shown to be most sensitive to the permeability of the water ice and dust layer. For a homogeneous, initially unmantled comet placed in the orbit of comet Halley, it is shown that the CO₂ ice attains a steady state or cyclic relationship between CO₂ depth and orbital position within several revolutions. If the nucleus contains 25% by mass of CO₂, our results indicate that CO₂ ice is always within several meters from the surface at any location for a nucleus of low obliquity and that CO₂ ice is nearest to the surface at the equator shortly after perihelion. Under these conditions the sublimation of CO₂ ice is always significant and becomes the dominant gaseous species beyond 4AU. This result is probably generally valid for unmantled portions of most comets and qualitatively simulates the behavior of an abundant, highly volatile component in an H₂O/silicate matrix. Comparison of these and similar results with observations could yield information regarding the permeability and chemical composition of cometary material and suggest sampling strategies to minimize fractionation effects.

Reference

Houppis, H.L.F., W.H. Ip and D.A. Mendis (1986). The chemical differentiation of the cometary nucleus: The process and its consequences. Astrophysical J., in press.