Radiolytic Cryovolcanism Revisited

John F. Cooper
Heliospheric Physics Laboratory, Code 672
NASA Goddard Space Flight Center
Greenbelt, MD 20771

Location of Enceladus within the inner magnetosphere of Saturn makes it likely that energetic electron irradiation, ion-neutral chemistry of the emergent cryovolcanic plume gas, and resultant radiolytic modification of surface ice composition could impact long-term evolution of molecular composition in the global ice crust. Thermally-driven convection of ice in the south polar terrain would bring radiolytic oxidant products into contact with subsurface reservoirs of primordial organics on million-year time scales. The chemical reactions leading to CO_2 gas production as a primary gas-piston driver of cryovolcanic activity would be exponentially elevated in the warm-ice margins of a heated fluid. The fluid temperature is typically assumed to be below 273 K but could be much higher in a gas-pressurized deep subsurface environment. The Perrier Ocean model has demonstrated how a CO_2-loaded fluid could account for the observed jets, while the heat content of the fluid arising from the moon's deeper interior could support high levels of chemical reactivity in the thermal margins. Since mass loss and tidal dissipation arguments do not support continuous activity over billions of years, the activity is likely very episodic so that even low-level energy sources including irradiation-driven radiolysis of surface ices could substantially contribute to the chemical dynamics of the activity apparently now in high phase. A multi-phase thermochemical model, and supporting laboratory measurements of temperature-dependent reaction rates, are needed to investigate these potentially complex processes.