Possible Endogenic and Atmospheric Processes Relevant to the Surface and Crustal Composition of Pluto: Insights from and Contrasts with Other Icy Bodies

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The major observed chemical species on Pluto (presentation by Grundy, this meeting) are probably just the most abundant of many substances, the tip of the chemical iceberg in terms of diversity. The chemical signature of photolytic processing of atmospheric methane (Cruikshank presentation, this meeting) is anticipated to be our first clue that resupply of methane from the interior has occurred and probably remains a recent dormant if not an active process. Cryovolcanism or sublimation-driven degassing of geologically/endogenically emplaced hydrocarbon deposits or of primordial clathrates is a likely process (Mousis presentation, this meeting). Cryovolcanism or geyser-like activity at Enceladus, inferred cryovolcanism at Titan, and degassing activity of comets gives some clues about how degassing and differentiation might occur at Pluto. By comparison to photolysis rates and tholin production on Pluto, endogenic transfers of volatile materials (McKinnon, Prockter, Howard, and Desch presentations, this meeting) might be far more important.

Once deposited, atmospheric remobilization and transport of hydrocarbons, aside from methane and ethane, is apt to be less considerable on Pluto compared to (a) Titan, where several hydrocarbons are volatile enough to be remobilized and transported through the atmosphere, or (b) icy Galilean satellites, where molecular ices can be transported (Spencer presentation, this meeting). Nitrogen and methane, however, can be transported significantly on Pluto, as they are on Triton (Young and Stansberry presentations, this meeting). Also unlike Titan, complex hydrocarbon liquid solutions and evaporitic solids are apt to be absent on Pluto's surface except as transient cryolavas. However, deep within the crust, many hydrocarbons, nitrogen, and argon may undergo melting and solid/liquid/vapor fractionation and venting onto the surface. Polar molecular solutions, including water, may be mobilized within the crust of Pluto and erupted onto the surface.

Oxygen- or sulfur-rich compounds and their specific molecular form, or their absence, as well as their global distribution, may be the key to divining whether endogenic activity (such as cryovolcanism), surface radiolysis, atmospheric photolysis, or atmospheric vapor transport and sublimation activity are in control of surface compositions. If surface solids are found to consist almost wholly of N_2-CH_4-CO, and are thick deposits, implications for Pluto's heat transfer are substantial and may point to a likely high aqueous activity deep in the crust. On the other hand, if these deposits are thin and discontinuous, the deeper icy crust may be much less active and older.

I will present some of these ideas from a context of multicomponent solid and solid-liquid phase equilibria and basic cosmochemical reasoning and offer a contrast and comparison of Pluto with Saturn's moons, Titan and Enceladus. I will consider these possible processes and explore how they might affect surface compositions, but discuss mainly from the perspective of solid-vapor and solid-liquid phase relations among the major atmospheric and surface constituents already identified or likely to be found on Pluto.