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# Organic-rich fluids in Pluto's interior—A source of cryovolcanic activity

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The highly variegated surface of Pluto revealed by the New Horizons spacecraft is composed of both volatile ices ($N_2$, $CH_4$, CO) and $H_2O$ ice, all of which are intrinsically colorless. The colors on Pluto reveal a non-ice component generally acknowledged to be a refractory complex organic material (tholins) produced by photolysis in the planet's atmosphere [1], and by photolysis and radiolysis of the surface ices [2-4]. These processes have produced a range of colors from pale yellow to red to brown, and result in a variation of a factor of 10 in albedo across the surface. Tholins are disordered polymer-like materials made of repeating chains of linked subunits and complex combinations of functional groups containing carbon. Nitrogen, oxygen, and other elements can be substituted in both the aliphatic and aromatic subunits. The detection of the spectral absorption of an ammoniated compound associated with surface exposures of red-colored $H_2O$ ice (herein, RAW) in the LEISA spectral mapping data from New Horizons suggests that a third source of a colored material is ejected from Pluto's interior as a water-rich fluid (cryomagma) that rapidly freezes at the low temperature (~40K) of the surface [5,6]. The ammoniated compound is thought to be an ammonia hydrate or an ammoniated salt; the spectral data cover a limited wavelength range, resulting in ambiguity in the identification of the form of the ammonia. The distribution of RAW in the vicinity of tectonically stressed and deformed geological structures, particularly graben (fossae), is seen as the result of both fluid effusion and fountaining ejection of cryoclastic materials in Pluto's Virgil Fossae region [5,6]. RAW is seen elsewhere on Pluto, both in association with graben complexes and on broad expanses of old surface, but primarily in zones of tectonic stress. The nature of the putative subsurface fluid is unknown, but it must have existed at relatively shallow depths such that the graben faulting could reach it. Geochemical modeling of fluids in the interiors of small planetary bodies in the outer Solar System [7] shows that ammonia-bearing $H_2O$ in contact with rock and metal components produce a rich chemical soup, including gases that can, in principle, help propel the fluid from shallow reservoirs through crustal fractures to reach the surface. An organic component of the fluid cryomagma is predicted to originate from thermal processing of the components [ref] and may be an example of one-pot synthesis of such complexes as amino acid precursors [ref] …

1. Gladstone et al.

2. Cruikshank et al. LPSC
3. Materese et al. 2014
4. Materese et al. 2015
5. Dalle Ore et al. 2019 NH3
6. Cruikshank et al. 2019