**ORGANIC MATERIALS ON PLUTO AND SATURN SATELLITES IAPETUS, PHOEBE, AND HYPERION.** Dale P. Cruikshank NASA Ames Research Center

In addition to the ices that cover the surface of Pluto, there is another component that is not an ice, and which produces a variety of colors that in some cases correspond to distinct geological units. This component is generally referenced as tholin, which is a refractory macromolecular material that exhibits colors ranging from pale yellow to dark red-brown, and even black. Tholins made in the lab by UV photolysis and charged-particle radiolysis of a Pluto-mixture of ices ($N_2$ + $CH_4$ + CO) mimic the colors of some regions on Pluto (Spencer et al. 2016). Analysis of the colored Pluto tholin analogs reveals a structurally complex mixture of carboxylic acids, ketones, aldehydes, amines, nitriles, and urea, among other organic components (Materese et al. 2015). The colored units on Pluto are thus reasonably regarded as organic in nature. Similar organic complexes are presumed to originate in Pluto's atmosphere by UV photolysis of the same molecules in gas phase; aerosol particles that grow from aggregation of macromolecules precipitate to the surface where they accumulate to depths that may reach meters in some geologically stable regions (Grundy et al. 2018). The full range of organic chemistry of Pluto's atmosphere, surface, and interior remain to be explored and clarified. Connecting the original and processed organic inventory of Pluto with other Kuiper Belt objects and the solar nebula is an overarching goal of the study of this material and its chemical history.

In the Saturn system, the red-colored, low-albedo material on one hemisphere of Iapetus has been shown to contain organic components revealed through spectral absorption bands in the region 3.0-3.8 μm. Analysis of data from VIMS on the Cassini spacecraft shows absorption bands of aromatic and aliphatic materials, though individual molecules cannot be identified (e.g., Cruikshank et al. 2014, and new work in progress). The superficial dark material on Iapetus is thought to have been ejected by impacts on Phoebe, a Saturn satellite that is generally thought to have formed in the Kuiper Belt region and subsequently captured by the planet in an inclined retrograde orbit. Thus, the organics on Iapetus (and Hyperion), as well as on Phoebe, may represent material from the solar nebula beyond 40 AU from the Sun, and hence may be indicative of the early organic chemistry in a cold region at the time of the formation of the planets.

REFS: Cruikshank, D. P. et al. 2014 Icarus 233, 306. Grundy, W. M. et al. 2018 Icarus (in press). Materese, C. K. et al. 2015 Astrophys. J. 812:150 (9 pp), October 20. Spencer, J. R. et al. 2016 AGU abstract.