PLUTO’S SURFACE COMPOSITION. W.M. Grundy1, D.P. Cruikshank2, S. Protopapa3, and B. Schmidt4. 1Lowell Observatory (Flagstaff AZ; w.grundy@lowell.edu); 2NASA Ames Research Center (Mountain View CA); 3Southwest Research Institute (Boulder CO); 4Université Grenoble Alpes, CNRS, IPAG (Grenoble France).

New Horizons’ instruments revealed spectacular compositional contrasts across Pluto’s surface [1]. Some of the most striking landscapes involve the volatile molecules methane (CH₄), nitrogen (N₂), and carbon monoxide (CO), frozen solid at Pluto’s low temperatures in the 35 to 60 K range [2]. These volatile ices have appreciable vapor pressure even at such low temperatures. Their volatility supports Pluto’s complex atmosphere [e.g., 3] and it enables them to sublimate and condense in response to daily and seasonally varying patterns of insolation [4,5]. The mobility of Pluto’s volatile ices enables significant transport over seasonal and longer timescales, creating a diverse array of landforms ranging from the penitente-like bladed terrain of Tartarus Dorsae [6,7], to the valley glaciers of eastern Tombaugh Regio [8,9,10], to the mantled, fretted, and pitted terrains at high northern latitudes [11]. Differences in the volatilities of N₂, CO, and CH₄ ices result in very distinct regional distributions, with the less-volatile CH₄ tending to occur at high altitudes and high northern latitudes at the time of the encounter, while the more volatile CO and N₂ were seen at mid-northern latitudes and in topographic lows [2]. A distillation sequence has been mapped in some regions where, initially, all three volatiles condense together, but the more volatile N₂ gradually sublimes away, followed by the CO, leaving a CH₄-rich residue [12]. One of Pluto’s primary reservoirs of N₂ ice is Sputnik Planitia [13,14], a partially-filled basin in which the N₂ ice deposit is so thick that it undergoes solid-state convective overturn, refreshing its surface in a way not seen in terrestrial glaciers [15,16]. At smaller scales, the surface of Sputnik is modified in some regions by the formation of sublimation pits [14,17], while other regions appear to be resurfaced by wind-blown dunes of CH₄ ice [18].

Underlying Pluto’s volatile ices is a comparatively non-volatile substrate dominated by H₂O ice. H₂O ice is detected spectroscopically in a variety of settings, often accompanied by dark reddish material. These include the rugged mountains in western Sputnik Planitia, that may consist of fragments of crustal material buoyantly supported in Sputnik’s N₂ ice. H₂O ice is also seen in Cthulhu and Krun, two examples from an equatorial belt of dark red maculae that appear to be too warm to condense much volatile ice [19,20]. H₂O ice also appears in association with dark, red deposits north of Cthulhu, such in the floors of craters and in Piri Planitia, a region where CH₄-rich scarps appear to have retreated, exposing substrate material [21]. Finally, H₂O appears associated with a variety of pits in eastern Tombaugh and further north, notably in Supay Facula. This class of H₂O deposits may be indicative of eruptive processes dredging it up from the interior and exposing it at the surface. Additional potential eruptive provinces have been identified in Wright and Piccard Mons [8,22], and in Virgil Fossae [23]. These regions will be discussed more in other talks. It is as-yet unclear what drives the eruptive activity, and whether it involves molten H₂O or Pluto’s more volatile materials that require much less energy to mobilize. Potential anti-freezes such as NH₃ and CH₃OH have been identified spectroscopically [24,25], and may assist in the mobilization of H₂O, now or earlier in Pluto’s history.

A third important class of materials on Pluto is complex organics, generally referred to as tholins. At the time of the New Horizons flyby, their production appeared to be dominated by UV photolytic chemistry in Pluto’s upper atmosphere [e.g., 26,27,28,29]. Photochemical products agglomerate into haze particles that settle out of Pluto’s atmosphere, accumulating at the surface. They are presumed to account for the dark red coloration of Pluto’s equatorial maculae, but where they settle on regions dominated by volatile ices they are evidently rapidly buried by seasonal volatile transport cycles. They may also interact chemically with molecules on Pluto’s surface, leading to further compositional evolution [30]. Some forms of energetic radiation are able to penetrate through Pluto’s atmosphere, driving chemical evolution of the surface ices themselves, and it is possible that during certain epochs, this mechanism could become a dominant driver of chemical evolution. A third potential source of organics is the subsurface, where molten H₂O and NH₃ can interact chemically with tholins incorporated into Pluto from the protoplanetary nebula [31]. Warmer subsurface temperatures enable chemistry to proceed much faster and are likely to lead to production of biologically interesting molecules, which could then be delivered to the surface environment via the various eruptive mechanisms mentioned earlier.

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made the mission a success. Names of Pluto surface features mentioned in this abstract include a mix of official and informal names.

References