RESEARCH ARTICLE SUMMARY

PLANETARY SCIENCE

Surface compositions across Pluto and Charon

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INTRODUCTION: The Kuiper Belt hosts a swarm of distant, icy objects ranging in size from small, primordial planetesimals to much larger, highly evolved objects, representing a whole new class of previously unexplored cryogenic worlds. Pluto, the largest among them, along with its system of five satellites, has been revealed by NASA's New Horizons spacecraft flight through the system in July 2015, nearly a decade after its launch.

RATIONALE: Landforms expressed on the surface of a world are the product of the available materials and of the action of the suite of processes that are enabled by the local physical and chemical conditions. They provide observable clues about what processes have been at work over the course of time, the understanding of which is a prerequisite to reconstructing the world's history. Materials known to exist at Pluto's surface from ground-based spectroscopic observations include highly volatile cryogenic ices of N_2 and CO, along with somewhat less volatile CH_4 ice, as well as H_2O and C_2H_6 ices and more complex tholins that are inert at Pluto surface temperatures. Ices of H_2O and NH_3 are inert components known to exist on Pluto's large satellite Charon. New Horizons' Ralph instrument was designed to map colors and compositions in the Pluto system. It consists of a charge-coupled device camera with four color filters spanning wavelengths from 400 to 970 nm plus a near-infrared imaging spectrometer covering wavelengths from 1.25 to 2.5 μm, where the various cryogenic ices are distinguishable via their characteristic vibrational absorption features.

RESULTS: New Horizons made its closest approach to the system on 14 July 2015. Observations of Pluto and Charon obtained that day reveal regionally diverse colors and compositions. On Pluto, the color images show nonvolatile tholins coating an ancient, heavily cratered equatorial belt. A smooth, thousand-kilometer plain must be able to refresh its surface rapidly enough to erase all impact craters. Infrared observations of this region show volatile ices including N_2 and CO. H_2O ice is not detected there, but it does appear in neighboring regions. CH_4 ice appears on crater rims and mountain ridges at low latitudes and is abundant at Pluto's high northern latitudes. Pluto's regional albedo contrasts are among the most extreme for solar system objects. Pluto's large moon Charon offers its own surprises. Its H_2O ice–rich surface is unlike other outer solar system icy satellites in exhibiting distinctly reddish tholin coloration around its northern pole as well as a few highly localized patches rich in NH_3 ice.

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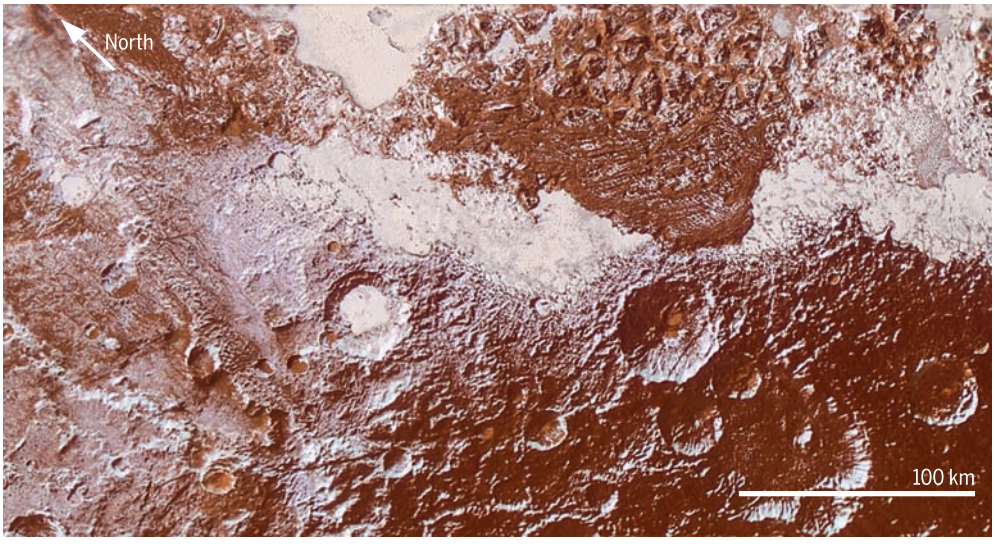
CONCLUSION: Pluto exhibits evidence for a variety of processes that act to modify its surface over time scales ranging from seasonal to geological. Much of this activity is enabled by the existence of volatile ices such as N_2 and CO that are easily mobilized even at the extremely low temperatures prevalent on Pluto's surface, around 40 K. These ices sublimate and condense on seasonal time scales and flow glacially. As they move about Pluto's surface environment, they interact with materials such as H_2O ice that are sufficiently rigid to support rugged topography. Although Pluto's durable H_2O ice is probably not active on its own, it appears to be sculpted in a variety of ways through the action of volatile ices of N_2 and CO. CH_4 ice plays a distinct role of its own, enabled by its intermediate volatility. CH_4 ice condenses at high altitudes and on the winter hemisphere, contributing to the construction of some of Pluto's more unusual and distinctive landforms. The latitudinal distribution of Charon's polar reddening suggests a thermally controlled production process, and the existence of highly localized patches rich in NH_3 ice on its surface implies relatively recent emplacement. ■



Enhanced color view of Pluto's surface diversity. This mosaic was created by merging Multispectral Visible Imaging Camera color imagery (650 m per pixel) with Long Range Reconnaissance Imager panchromatic imagery (230 m per pixel). At lower right, ancient, heavily cratered terrain is coated with dark, reddish tholins. At upper right, volatile ices filling the informally named Sputnik Planum have modified the surface, creating a chaos-like array of blocky mountains. Volatile ice occupies a few nearby deep craters, and in some areas the volatile ice is pocked with arrays of small sublimation pits. At left, and across the bottom of the scene, gray-white CH_4 ice deposits modify tectonic ridges, the rims of craters, and north-facing slopes.

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