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Bladed Terrain on Pluto: Possible Origins and Evolution

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Abstract

We conclude that Bladed Terrain on Pluto is a deposit of massive CH_4, which preferentially precipitates at high elevations, and has since its initial formation, undergone episodes of sublimation erosion that has given this deposit its characteristic texture.

1. Introduction & Observations

Bladed terrain on Pluto is observed to occur within latitudes 30° of the equator and found almost exclusively on the highest elevations (>2 km above the mean radius) where observed in the hemisphere best seen by *New Horizons* (Fig. 1). Well-developed blades are typically spaced ~3 - 7 km crest-to-crest, have a typical local relief of ~300 m, and flank slopes of ~20°. Blades dominantly display a N-S orientation, but those near the equator additionally exhibit a more rectilinear pattern. The blades are located on broad ridges averaging ~100 km wide (Tartarus Dorsae), separated by troughs that appear to be of structural origin. Color data of the non-encounter hemisphere hint that Bladed Terrain may extensively occur within the ±30° latitude band. As such, these putative Bladed Terrain regions presumably also occur at high elevations.

2. Analysis

Observations do not readily point to a single simple analogous terrestrial or planetary process or landform. We have separately considered the origin of the Bladed Terrain Deposits (BTD), and the bladed textures on their surface. The latter may have developed at a later time and by a different process. We first considered processes that form both the deposits and the blades themselves (endogenic extrusion and aeolian sand erg development). The principle objection to these hypotheses was that the blades occur on ridges rather than in depressions, as is commonly seen for these processes on other planetary surfaces. Instead, the strong correlation of BTD occurrence with high elevation suggests an atmospheric temperature control and source for their presence and modification. During the time of the encounter, with the exception of the 1 km-thick boundary layer exclusively above Sputnik Planitia, Pluto's lower atmosphere temperature profile displayed an increase with altitude. The consequence of warmer air temperatures at higher altitudes is that the condensation of N_2 ice is suppressed, while the formation of CH_4 ice is currently promoted at high elevation. Changes in atmospheric mass can encourage erosion of CH_4 ice. We conclude that since the time the BTD were emplaced, there have been sufficient excursions in Pluto's climate to partially erode these deposits into the blades we see today. The blades themselves are partially analogous to penitentes on terrestrial, low-latitude, high-elevation ice fields [1], [2]. The processes that contribute to, and control the amplitude and spacing of, the blades are not yet fully understood. For instance, these Plutonian blades are at least two orders of magnitude larger than terrestrial penitentes. Plutonian blades may be entirely erosional, like terrestrial penitentes, or may form by erosion at the base and condensation at the crests, which is marginally permitted in Pluto's current climate at those altitudes.

3. Conclusions & Implications

We suggest that the west to east sequence of landform elements from the lowlands of Sputnik Planitia, through the Bright, Pitted Uplands, to the BTD are genetically related and are driven by ices sublimated from Sputnik Planitia and condensed (and further modified) on the uplands to the east. The Bright, Pitted Uplands and the BTD occupy the same

latitude belt and manifest a surficial compositional sequence from dominance by N_2 ice closest to Sputnik Planitia (including return-flow N_2 glaciation) to increasing dominance of CH_4 ice to the east culminating in the BTD. This compositional sequence corresponds to an altitudinal control on ice stability, with only CH_4 being stable at high relative elevations. Atmospheric modeling to date has not demonstrated an eastward circulation in the equatorial latitude belt [3] under orbital and seasonal conditions during encounter. On the other hand, the high albedo of the Bright, Pitted Uplands suggests N_2 and CH_4 ice deposition has occurred in this latitude belt east of Sputnik Planitia within the recent geologic past. Thus Bladed Terrain, along with other deposits of volatiles in Tombaugh Regio proper (including Sputnik Planitia), represents an active response of the landscape to current and past climates.

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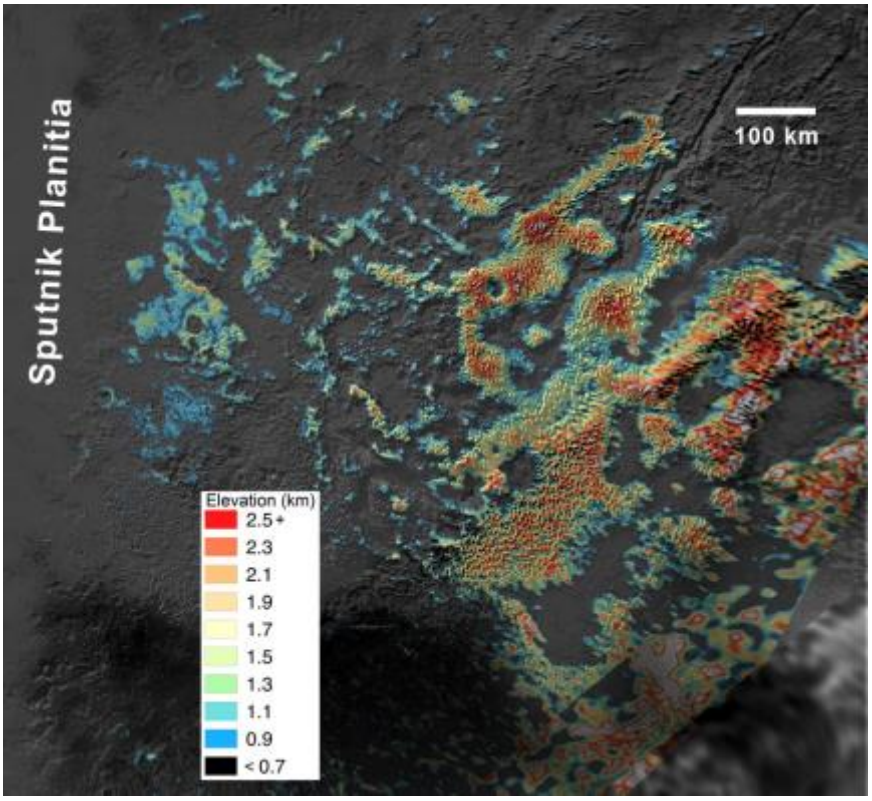

Figure 1. Outcrops of Bladed Terrain are strongly correlated with elevations of around +2 km and above (relative to the mean planetary radius of 1188.3 km).