

ARE THE SURFACE TEXTURES OF PLUTO'S WRIGHT MONS AND ITS SURROUNDINGS EXOGENIC? J.M. Moore¹, A.D. Howard², O.L. White^{1&3}, O.M. Umurhan^{1&3}, K.N. Singer⁴, P.M. Schenk⁵

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Introduction: The Wright Mons region of Pluto remains one of the most intriguing and enigmatic landscapes on the planet. Wright Mons is a large mountain ~150 km across that rises ~4 km above its surroundings, sports a central depression that is ~45 km across and ~4 km deep, and was tentatively assigned a cryovolcanic origin immediately following the *New Horizons* encounter in 2015 (Fig. 1) [1,2,3]. But the absence of obvious lateral flow features and the lack of unambiguously diagnostic characteristics of calderas or vents within the central depression have challenged the development of specific formation hypotheses. The pervasive cover of pillow-like hummocks, typically 7-20 km across, on the flanks and surroundings of Wright Mons have naturally figured into various working explanations for the formation of this region (Fig. 2). Individual hummocks themselves are covered by a km-scale blocky texture. The similarity in size and shape of the convex hummocks and the style of their organization, such as forming a vaguely concentric fabric near the summit, potentially lend themselves to an endogenic origin.

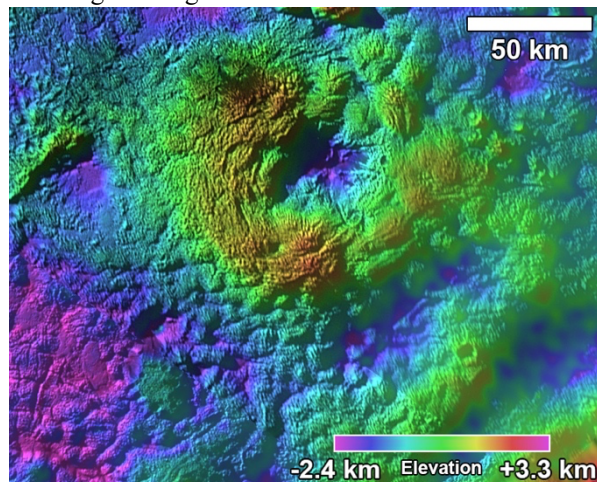


Figure 1. Wright Mons and surrounding terrain. Colorized digital elevation model overlain on 315 m/pixel New Horizons imaging. North is to the top-left and illumination is from the top-left.

Hypothesis: Here we entertain an alternative hypothesis for the development of the hummocky terrain, specifically that it represents accretional accumulation of volatiles that have precipitated from the atmosphere, rather than viscously flowing, endogenically sourced cryolavas. The closely packed dome-like structures form a botryoidal (or globular) texture that is remarka-

bly similar to the convex outward crystalline deposits seen on cave walls (Fig. 3) [e.g. 4]. These form by uniform surface-normal accretion, whereby radial growth at the same rate around multiple nuclei causes individual formations to abut and merge with neighboring ones, resulting in convex outward bulges separated by narrow, deep seams. If accretion is absolutely uniform, the convexity of the bulges gradually declines, as does the relative relief. If, however, the accretion rate depends positively on the broad-scale convexity, then the bulges will remain stable or grow in convexity as more material is added. This will also happen if the rounded summits of the bulges accrete more rapidly than the seams (due to more exposure to volatile deposition).

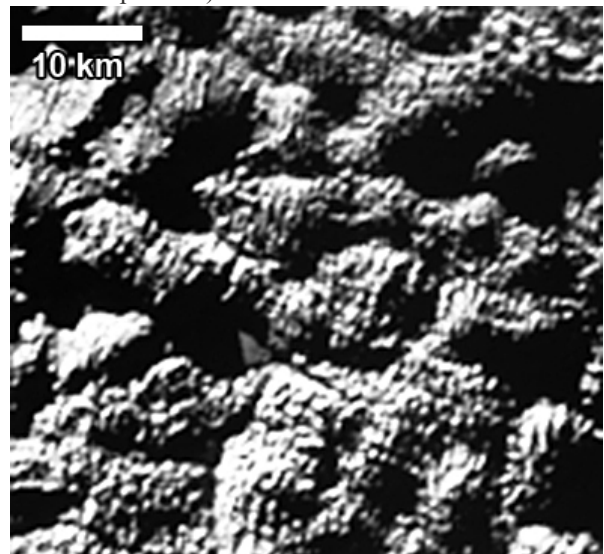


Figure 2. Close-up of the pillow-like hummocky texture that characterizes the flanks of Wright Mons and surrounding terrain. North is up and illumination is from the top-left.

Discussion: In this hypothesis, the formation process of the hummocks is somewhat analogous to that which has been proposed for the bladed terrain deposits of Tartarus Dorsa in Pluto's equatorial region [5]. A comparison between the hummocky terrain and the bladed terrain is that both display two or three intrinsic spatial scales. The bladed terrain deposits form broad, convex outwards mounds separated by 90-150 km, which themselves feature low rises ~50 km across, while individual blades are spaced ~4 km apart. The deposits themselves are interpreted to have formed during a sustained climate era that permitted high-

altitude condensation of methane, while the blades are interpreted as evidence that the climate of Pluto has changed such that, overall, sublimation erosion of the methane is now occurring [5]. In the case of the Wright Mons area, spacings are smaller but also of three scales. The major ridges and the Wright Mons peak-to-opposite peak distance is about 70-90 km, the domes of the hummocky terrain are 7-20 km diameter, while the hummocky terrain also displays an etched (or at least blocky) appearance at a scale of hundreds of meters to a few kilometers that seems to display a subtle N-S-oriented fabric. As with the bladed terrain, this etched texture may indicate that the material forming the hummocks has experienced sublimation erosion subsequent to its emplacement. Factors that might determine the spatial scales include creep relaxation, atmospheric convective length scales, and atmospheric inversion heights.

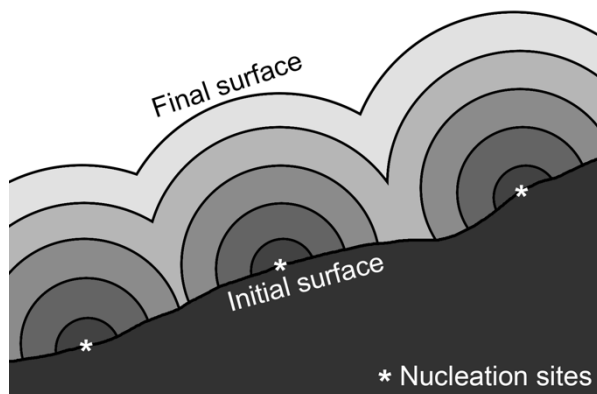


Figure 3. Development of botryoidal texture by surface-normal accretion at separate nucleation sites. Evolution of the surface is indicated by progressively lighter shades of gray.

The accretion hypothesis must explain the source of the volatiles, however, and why they deposited in the locations where they are observed. The methane ice of the bladed terrain deposits preferentially precipitated at high altitude (where nitrogen ice cannot precipitate), and is concentrated within the equatorial diurnal zone to the east of Sputnik Planitia (perhaps on account of atmospheric retrorotation pushing gaseous methane westwards [6]). The hummocky terrain of Wright Mons and its vicinity, however, is much more localized relative to the bladed terrain deposits, being concentrated at the southern end of Sputnik Planitia within an area measuring ~400 by ~300 km, and extends across an elevation range of 7 km. This distribution would imply that if the hummocky terrain does have an accretional origin, it likely does not stem from precipitation of volatiles as governed by global climate dynamics, but rather from precipitation of locally sourced volatiles. A subsurface origin would be the

most feasible in this scenario, with volatile outgassing analogous to fumarolic activity, rather than eruption in solid/liquid phase via effusive or fountaining activity. The rimless depressions seen at the center of Wright Mons and in its surroundings might represent the sources for such outgassing. An accretional origin may explain why the hummocky terrain appears to “colonize” Wright Mons and neighboring landforms regardless of their topographic relief. It is perhaps difficult to comprehend why, if the individual hummocks represented domes of viscously effused cryolava, they would be spaced roughly equidistantly across such uneven terrain (which can attain slopes exceeding 20° at Pandemonium Dorsa and Wright Mons itself) rather than concentrating in certain areas at the expense of others.

Yet while the accretional hypothesis may offer an explanation for the hummocky terrain as an accumulation of precipitated volatiles covering the landscape, there remains the question of the origin of the unique large-scale topography of this region as represented by Wright and Piccard Montes, Pandemonium Dorsa, as well as other features such as the 78 km by 63 km domical feature surrounded by a trough that is located to the west of Piccard Mons at 36.2°S, 167.4°E. Piccard Mons and its surroundings display a rough texture, but one that does not appear as hummocky or ordered as that seen at Wright Mons, although the fact that Piccard Mons was only seen in haze imaging may be a factor in explaining its different appearance. The morphologies of Wright and Piccard Montes consist of quite flat-topped annuli surrounding steep slopes. For the sake of argument, this might be explained if they were originally large impact craters that have both experienced accretion of volatile ice deposits reaching hundreds of meters to kilometers thick. If this were so, it would mean, however, that they do not in fact represent centers of cryovolcanic activity and so cannot be a source of outgassed volatiles.

It remains significantly more probable that the large edifices that are a characteristic of this part of Pluto are derived in some way from cryovolcanic processes, with the hummocky terrain being diagnostic of a style of cryovolcanism that is particular to Wright Mons and its surroundings, whether that be extrusion of viscous cryolava to form domes, or botryoidal accretion of volatiles outgassed from vents.

References: [1] Moore J. M. et al. (2016) *Science*, 351, 1284-1293. [2] Singer K. N. et al. (2016) LPSC XLVII, Abstract #2276. [3] Schenk P. M. et al. (2018) *Icarus*, 314, 400-433. [4] Klein C. & Hurlbut C. S. (1985) *Manual of Mineralogy*, 20th Edition, p. 199, John Wiley and Sons. [5] Moore J. M. et al. (2018) *Icarus*, 300, 129-144. [6] Bertrand T. et al. (2020) *J. Geophys. Res. Planets*, 125, e2019JE006120.