THEORETICAL UNDERPINNINGS ON AEOLIAN TRANSPORT ON 2014 MU_{69} "ULTIMA THULE."

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Introduction: NASA's New Horizons spacecraft flew past the cold classical Kuiper Belt object 2014 MU_{69} (informally named "Ultima Thule;" hereafter UT) on January 1, 2019 from 3500 km. As a result of the reconnaissance, UT was discovered to be a contact binary, the first such world observed in situ [1,2]. The total length of UT is approximately 33 km in which the ratio of the two lobes' diameters is approximately 10:7.

The contact point between the two lobes of UT shows higher reflectance, ~1.5x, than the rest of the body, possibly due to finer grain sizes; higher reflectance could alternatively be attributed to differences in composition or age. From future higher resolution images (35 m/px) and data to be downlinked in early March, 2019, we will report on the detection of any ripples, dunes, yardangs, wind tails, sediment-filled depressions, sediment slope streaks, cross bedding, etc. as previously predicted [3]. Additionally, ejecta facies from the initial "docking" (~1 m/s collision) of UT's two lobes may be visible. The observed landforms will provide insight into the geologic processes responsible for their formation.

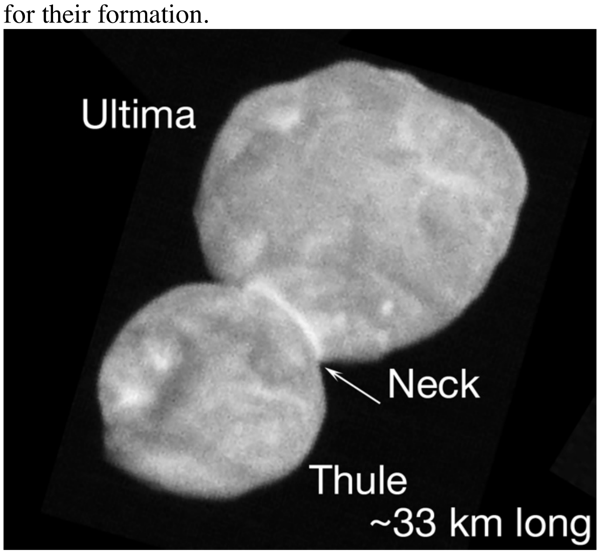

Figure 1. Image of Ultima Thule from the early downlink in January 2019, with a surface pixel scale of ~140 m/px (Image ID lor_0408624825_0x630_sci.fit). Images with pixel scales as fine as ~35 m/px from the February 2019 downlink could show sedimentary geology features, most likely near the neck due to the steep slopes.

Aeolian Transport Theory: Cheng et al. [4] and Thomas et al. [5,6] modified the aeolian transport theory of [7] and applied it to the rarefied, volatile-rich environment of Comet 67P, roughly an analog world to UT. Building on this theory, [5,6] further developed a conceptual model that could work independently of, but along with, the modified Shao and Lu model.

In aeolian geology, fluid drag forces lift and transport particles downwind, often expressed by [7] as the threshold wind friction speed

$$u_t^* = \sqrt{A_N\left(\sigma g d + \frac{\gamma}{\rho d}\right)}$$

where the variables are described in Table 1. [4,5,6] showed that particles can be lifted in the low gas density and low gravity environment of a comet, though they further argued fluid lift was not necessary [5,6]. Instead, falling grains initially lofted by sublimation could nudge surface grains on short hops and rolls (reptation and creep), leading to the creation of aeolian-like ripples.

We posit that the most likely source of exposed volatiles (N_2, CO) would be from the accreted ("splatted") low density, low velocity (~300 m/s [8]) impactors. The process of splatting may do two things: (1) mostly expose the volatiles in the impactor so that the accreted material is more prone to erosion than the surrounding terrain, which may produce some distinctive morphologies and aeolian flow features; and (2) Disturb the non-volatile surfacial lag deposits that has armored the surface from slow sublimation.

Over the 4+ billion year lifetime of Ultima Thule, we thus expect sublimation-mobilized airfall grains and low-speed impact ejecta to have operated and affected granular surface landforms. Any early out-gassing could likewise have mobilized grains in the manner of [5,6,7]. Potential granular surface landforms could include ripples related to aeolian-like processes (e.g., Figure 2), especially in the likely sediment-rich environment of the neck. The ~35 m/px images of UT's neck region to be downlinked around March 1, 2019 will allow us to test these hypotheses.

References: [1] Stern, S.A., et al. (2019) 50th LPSC, *This Conference* [2] Moore, J.M., et al., (2019) 50th LPSC, *This Conference* [3] Moore, J.M., et al., (2018) GRL, 45, doi: 10.1029/2018GL078996. [4] Cheng, A.F., et al. (2013), Icarus, 808-817, doi: 10.1016/j.icarus.2012.10.004. [5] Thomas, N. et al. (2015) LPSC Abstract #1712. [6] Thomas, N., et al., (2015), Astronomy and Astrophysics 583, A17, doi: 10.1051/0004-6361/201526049. [7] Shao, Y., Lu, H., (2000), JGR, 105, D17, p. 22,437-22,443, doi: 10.1029/2000JD900304. [8] Greenstreet, S., et al. (2018), Crater Density Predictions for New Horizons flyby target 2014 MU69 pre-print.

Table 1. Description of variables from the Shao and Lu equation.

u^*_t	Threshold wind friction speed required to move sand via saltation
A_N	Parameterizes effects of interparticle cohesion.
σ	Ratio of particle to gas density
g	Gravitational acceleration
d	Average grain diameter
γ	Related to grain cohesion
ρ	Grain density

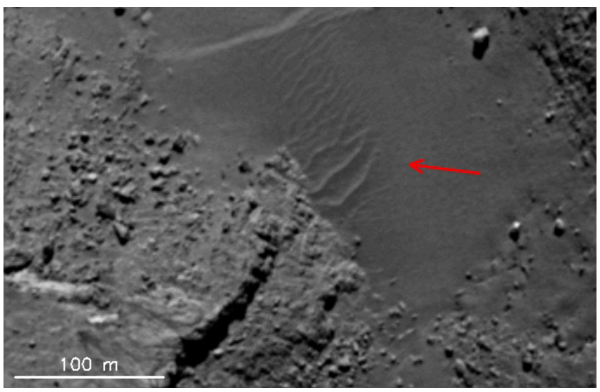

Figure 2. Ripples on Comet 67P in the neck region observed by Rosetta [5].