KUIPER BELT OBJECT 2014 MU_{69}: CORRELATION BETWEEN ALBEDO AND LANDFORMS

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Introduction: 2014 MU_{69}, nicknamed Ultima Thule and heretofore referred to as MU_{69} [1], is the first Kuiper Belt Object (KBO) to be observed at close range by a spacecraft. It is a cold classical KBO that formed beyond the orbit of Neptune and has remained in a stable, relatively circular, and low inclination orbit since formation [2]. Although the surfaces of cold classical KBOs have likely been modified to some extent by radiation and collisions, it is possible that their interiors contain material that is unchanged since it condensed from the solar nebula 4.6 billion years ago [3]. New Horizons visited MU_{69}, roughly 4 billion miles away (MU_{69} is currently at 43 AU), on 1st January, 2019 (UTC).

Observations: The highest resolution images downlinked from New Horizons to date show that MU_{69} is a bi-lobate contact binary (Figure 1); the bigger lobe is informally called Ultima (9.73 km diameter) and the smaller lobe is Thule (7.12 km diameter). A 140 m/pixel image reveals a mottled appearance to MU_{69}'s surface, with both relatively dark and light albedo material on its surface (Figure 1). The total I/F range is 0.06 to 0.14 [4]. A distinctly high albedo feature (I/F = 0.14) appears at the binary interface between the two lobes (informally referred to as the "neck"). The MVIC (Multi-spectral Visible Imaging Camera) data [5] indicate that the neck feature appears less red compared to the rest of MU_{69}. The bright material here forms a subtle dendritic and possibly radial pattern around the neck (Figure 2). The steepest slopes on MU_{69} are encountered near the neck [6], raising the possibility that high albedo, poorly consolidated, and bluer (and therefore fresher) material is collecting here. A similar brightening at the neck is also seen at the Hapi region of the neck of comet 67P C-G[8].

Additional high albedo features are observed elsewhere on MU_{69} (Figure 1). For example, Ultima's distal end displays an arc of bright material with a subtle dendritic pattern (Figure 3). The limb topography of Ultima shows what might be a dome at this location (yellow arrow in Fig. 1) [7], and the bright material may be collecting in a trough at its base, in a topographic context that may be comparable to, but less extreme, than what is encountered at the neck. The dendritic pattern may be caused by material collecting in valleys branching off the main trough. No unambiguous impact craters have yet been detected on MU_{69} [9,10], but bright patches up to a few kilometers across on both Ultima and Thule (orange arrows in Fig. 1) may potentially represent bright ejecta or bright material collected on the floors of impact craters. The low phase angle in available image means that we can't infer topography from shape-from-shading at the moment.

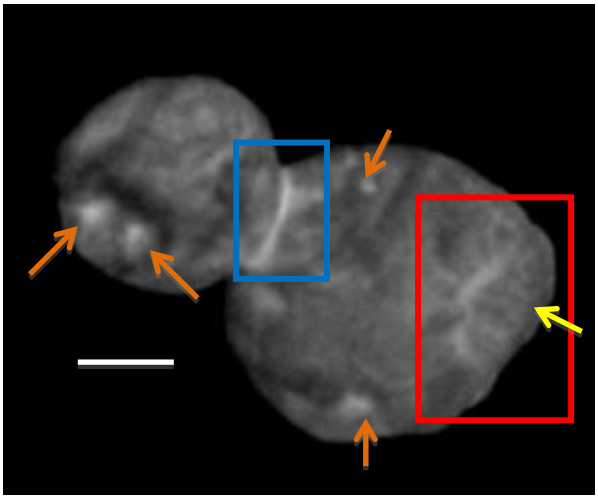

Figure 1 : 2014 MU_{69} (Ultima Thule) as seen by New Horizons' LORRI (LOng Range Reconnaisance Imager) camera (Image ID: CA04-MAP L1 2019001). The sun is almost behind the spacecraft in this image (phase angle of ~13°) and the pixel scale is 140 m/pixel. The high albedo neck is seen in the blue box (expanded in Fig. 2). The red box shows an arc of high albedo material near the distal end of Ultima (expanded in Fig. 3). Yellow arrow points to a possible dome on the limb of Ultima. Orange arrows point to bright patches a few km across. Scale bar is 5 km.

Implications: The high albedo material, particularly near the neck, appears to be associated with high slope regions, and so the origin of these bright materials

could potentially be related to processes such as diffusion and mass wasting. If the bright material has been freshly exposed, it will provide valuable insight into our understanding of the surface processing histories of classical KBOs. The cause of the high albedo may be attributed to differences in composition or grain size.

Forthcoming data: Data currently stored on board New Horizons will continue to be downlinked over 2019 and 2020. The highest resolution data to be downlinked will be received in February 2019, and will have a pixel scale of ~30 m/pixel and a phase angle of >30°. This data will be received before the 50th LPSC, and will allow us to better characterize the surface geology and topography of MU_{69}, and therefore more confidently assess the relationship of the distribution of high albedo material to topography across its surface. The albedos, colors, compositions, and solar phase scattering properties of separate high albedo regions will also be compared. Combining these various datasets will help us understand the nature and origin of MU_{69}'s bright material. [11,12].

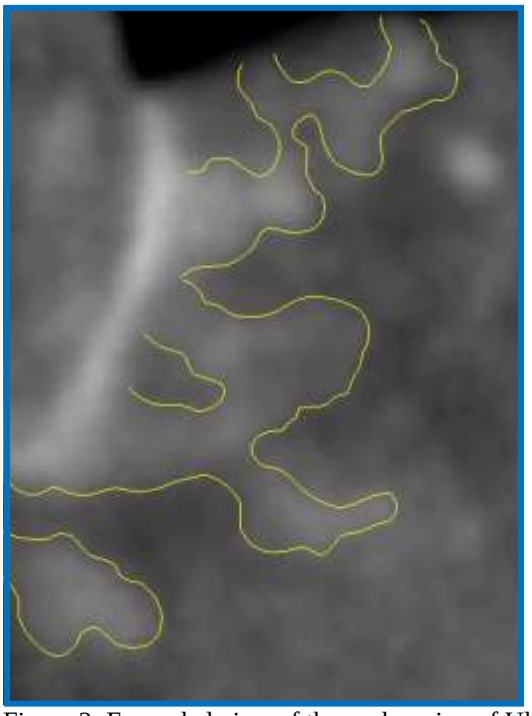

Figure 2: Expanded view of the neck region of Ultima Thule (location shown by blue box in Figure 1). The distribution of high albedo material surrounding the neck feature is outlined in yellow.

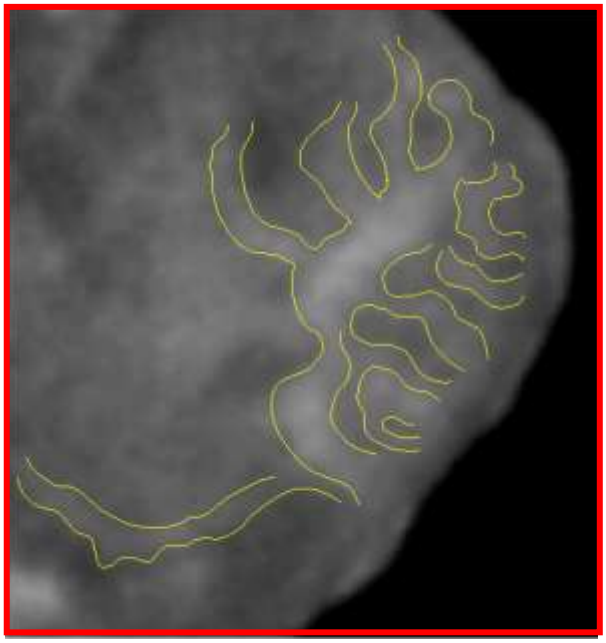

Figure 3: Expanded view of Ultima (location shown by red box in Figure 1). A dendritic-like distribution of high albedo material is outlined in yellow.

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