EPSC Abstracts
Vol. 13, EPSC-DPS2019-1140-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Topography of Pits & Troughs on Ultima Thule (2014mu69) from New Horizons

Paul Schenk (1), Ross Beyer (2,3), Chloe Beddingfield (2,3), Jeffery Moore (2) Cathy Olkin (4), John Spencer (4), Hal Weaver (5), S. Alan Stern (4) and the New Horizons Team. (1) Lunar and Planetary Institute, Houston (schenk@lpi.usra.edu), (2) NASA Ames Research Center, MS 245-3, Moffett Field, CA, 94035 (3) The SETI Institute, CA, (4) Southwest Research Institute, Boulder, CO, (5) JHU-Applied Phys. Lab., Laurel, MD.

Abstract

Topographic data of Ultima Thule from the New Horizons encounter, though limited, provide our only constraints on the relief of geologic features. Stereo DTMs provides important information on the shape of the body but do not resolve smaller geologic structures. Craters or pits >1 km are observed on the terminator region of "Ultima". Here we use photoclinometry to show that these features appear to be very shallow, with d/D of <0.06 (pending photometric updates). Linear troughs crossing "Ultima" are also very shallow. This shallow topography is consistent with the general lack of prominent relief on the two lobes as derived from stereo, and is consistent with the geologic interpretation that the level geologic activity, both exogenic and endogenic, on Ultima Thule (and by extension other small KBO's) is limited.

1. Introduction

The New Horizons encounter with the small Kuiper Belt object, 2014 MU69 (nicknamed Ultima Thule) presents the first opportunity to examine the geology and topography of a small, bilobate, nearly pristine, icy cold classical KBO [1]. The best images were acquired at pixel scales of ~32 meters, and approach imaging at lower resolutions provides stereo coverage. Shape models derived from rotation and stereo studies indicate two flattened lobes in contact with each other [2, 3, 4]. Here we focus on smaller scale structures related to surface geology.

While not heavily cratered or fractured, Ultima Thule does feature several dozen circular to oval shaped pits and linear troughs. Whether the troughs could be related to the assembly of Ultima Thule is a matter of debate [2]. Stereogrammetric DTM construction uses scene recognition algorithms to determine parallax and do not resolve these features. Here we use photoclinometry (PC) or shape-from-shading to resolve these features at pixel scales. This technique is dependent on a photometric model of brightness variation with solar illumination. Thus, values presented here are preliminary pending updates to Ultima Thule photometry. Photoclinometry on icy bodies works best in regions with high solar incidence angles (>60°). Due to the phase angle of the best images (~35°) the only regions observed with these incidence angles were the terminator region of the larger "Ultima" Lobe (Fig. 1), and small areas of the smaller "Thule" Lobe (which will also be reported on at the meeting).

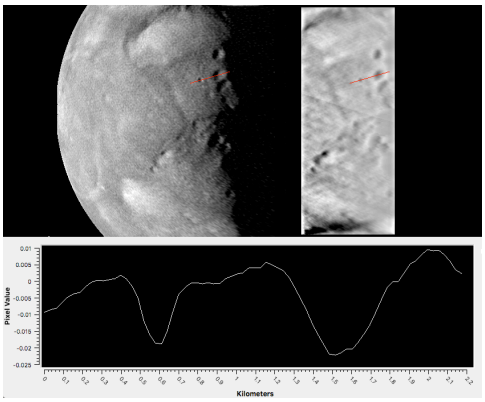

Figure 1: Othographic projection (left) and coincident PC-DTM (right) centered on terminator region of "Ultima" lobe. Profile line includes two circular pits of different size.

2. Pits

Approximately 10 pits were observed in the terminator region of Ultima (Fig. 1), which vary in size from <300 to ~650 m across. These pits resemble conical simple craters, but the alignment of

some pits with troughs suggests possible endogenic origin due to venting or collapse [2]. Depth/diameter ratios are in the 0.05 range, extremely shallow for normal simple craters in ice (typically 0.15-0.2). Relaxation is not expected though sublimation or space weathering might degrade crater depths over time. While potentially indicative of endogenic origins, the low impact velocities expected on Ultima Thule (roughly 300-350 m/s) could also produce shallow craters. (We note that some pits closest to the terminator may be minimum depths due to shadowing.) Whether they could produce craters this shallow (pending photometric updates) is uncertain.

3. Troughs

The linear troughs evident on Ultima Thule have low relief and rounded or smoothed edges. Whether the lack of sharp edges is due to erosion or a non-graben faulting style is unknown. The relief across the two troughs we have PC data for (Fig. 2) is also very shallow ($\leq$10 m). Evidently the amount of extension is either very limited or erosive processes have degraded these structures since their (presumably) early formation.

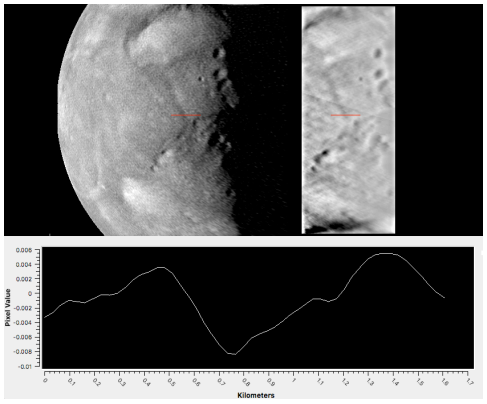

Figure 2: Othographic projection (left) and coincident PC-DTM (right) centered on terminator region of "Ultima" lobe. Profile line includes one of two linear troughs visible in the terminator region.

4. Summary and Conclusions

Topographic data for Ultima Thule from the New Horizons encounter are important but very limited. With the exception of the large 3-km impact structure on "Thule," no craters or pits >1 km are observed. Pits observed along the terminator appear to be very shallow, with d/D of <0.06 (pending photometric updates). Linear troughs crossing "Ultima" are also very shallow. This shallow topography is consistent with the general lack of prominent relief on the two lobes as derived from stereo, and is consistent with the geologic interpretation that the level geologic activity both exogenic and endogenic on Ultima Thule (and by extension other small KBO's) is limited.

Acknowledgements

We thank NASA for financial support of the New Horizons project and we thank the entire New Horizons team for making the results of the flyby possible.

References

[1] Stern, S.A., et al.: Initial results from the New Horizons exploration of 2014 MU69, a small Kuiper Belt Object. Science 364, eaaw9771, doi:10.1126/science.aaw9771, 2019.

[2] Spencer, J et al., submitted, Science, 2019.

[3] Porter, S.B., et al. The Shape and Pole of (486958) 2014MU69. DPS/EPSC (this conference), 2019.

[4] Beyer, R.A., et al. Stereo Topography of KBO (486958)MU69. DPS/EPSC (this conference), 2019.