**TRITON v. PLUTO: TOPOGRAPHY MAPPING OF TWO KUIPER BELT OCEAN WORLDS.** P. Schenk[1], T. Stryk[2]. S.O'Hara[1], W.B. McKinnon[3], J. M. Moore[4], J. T. Keane[5], C.B. Beddingfield[4], R. Beyer[4] and L. Prockter[1], [1]Lunar and Planetary Institute/USRA, Houston, TX, (schenk@lpi.usra.edu), [2]Roane State C. College, Oak Ridge, TN, [3]Dept. Earth & Planetary Sci. McDonnell Center for Space Sci., Washington University in St. Louis, Saint Louis, MO 63130, [4]SETI Institute & NASA Ames Res. Center, Moffett Field CA, [5]Calif. Inst. Technol., Pasadena, CA.

**INTRODUCTION:** With the discoveries of candidate and confirmed ocean worlds from Ceres to Pluto, and the publication of the Roadmaps to Ocean Worlds study [1], interest has been renewed in the active icy moon Triton [2] and its place as a likely ocean world. A Discovery-class mission to Triton is possible and has been proposed [3]. Although studied extensively from Earth, only one spacecraft (Voyager 2) has visited this moon and returned resolved data (using 1970s era instrumentation) [2]. Here we examine the topography of Triton [a new color map was described in 4] with emphasis on topographic comparisons to Pluto as observed by New Horizons [5].

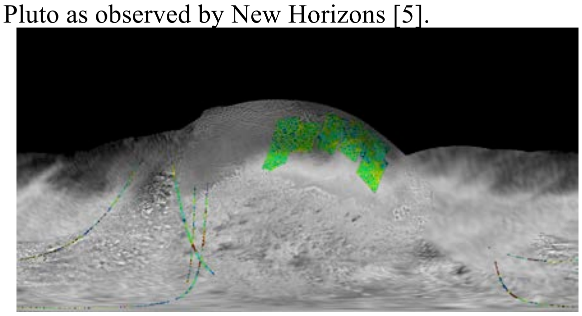

*Figure 1. Revised global mosaic of Triton, color coded to show limb and stereo DEM topography (red high, blue low; range shown -1 to +1 km).*

**Triton Topography:** Resolved Triton imaging included the illuminated portion of the encounter (Neptune-facing) hemisphere in 1989 at pixel scales ranging from ~1.6 to ~0.35 km. While much of this imaging was nominally stereo, Triton topography proved to have very low amplitudes and parallax was insufficient to resolve geologic features in most cases. There are important exceptions: Voyager stereo was more than sufficient to detect several atmospheric plumes originating as narrow columns that fan out at ~8 km altitude due to upper level winds [6]. Visual examination of suggests that there could be additional lower level plumes that do not reach the 8 km shearing altitude. The only geologic features resolved in the DEMs are the cells within the eastern cantaloupe terrain of Bubembe Regio [7] (Fig. 2).

Use of stereo data to constrain regional-scale topography is hampered by the chronically subdued topography and by the compression used to return the approach hemisphere mosaic images. Compression resulted in alternating line dropouts along the left and right sides of the images, erasing half of each reseaux in those areas (reseaux are fiducial markings on the Voyager vidicon plate used to remove camera distortions). Removal of half a reseau leads to unknowable errors in its position and the knowledge of the camera distortions necessary for image projection and stereogrammetry (and which may have unknown distortion effects on intact reseaux in the center sections). In some cases obvious vertical distortions are evident in the DEMs at the locations of the edges of the original frames. These are removed using a digital destriping tool, but the absolute magnitude of the distortions are unknowable. Lastly, 7 of the 10 high resolution CA images were smeared, rendering stereo matching suspect and introducing DEM noise. Here we use desmeared versions resulting in improved DEMs.

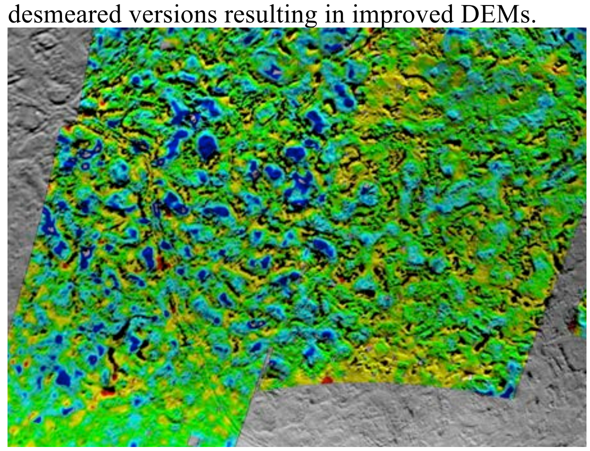

*Figure 2. Enlargement of Figure 1 showing best steregrammetric DEM on Triton, over convective cells in cantaloupe terrain (red high, blue low; range shown -1 to +1 km). These data were derived from global mapping mosaics at 1.6 to 1.0 km pixel scales and high-resolution mosaic near closest approach at 350 m pixel scales, which allow construction of DEMs with nominal vertical precisions of ~200 m.*

It is particularly concerning that there remains so little useful topography for southern terrains, where the plumes are [6]. None of the limb tracks derived to date [8] overlap the high resolution mosaics, including southern area. Several high spots south of the equator may correlate with either dark regions or plume trails. The scant limb profiles [8] indicate that the heights of observed geologic features and terrains are <1 km.

The heights of individual geologic features on Triton can be determined using photoclinometry (Fig. 3). These data have large long-wavelength uncertainties but in general are reliable to within ~10% for small-scale features. These data cover the terminator region and confirm the inference from stereo that no geologic features are >1 km in height.

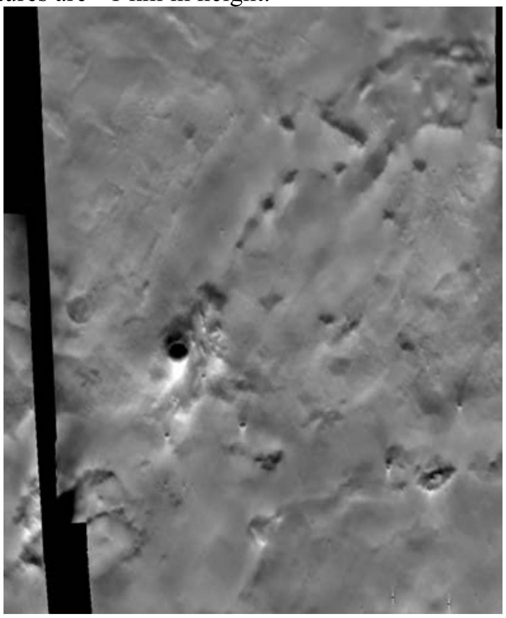

*Figure 3. Portion of a topographic map for equatorial Triton based on photoclinometry. Area shown is 800-km wide and total amplitude of 1 km is shown. Leviathan Patera is the 80-km-wide circular feature at lower left; pit chains and volcanic plains to upper left.*

**Triton Geology:** One surprise from the New Horizons Pluto encounter was the limited number of analogous terrains on Triton and Pluto. The oval convective cells of Sputnik Planitia nitrogen ice sheet bear a superficiall resemblance to the oval convective overturn structures in the Bubumbe Regio cantaloupe terrains, and are of similar scale (typically 20-40 km [7]). On Pluto, these oval cells are gentle positive features 100-200 m high whereas the cantaloupe cells are on the order of 500 m deep and flanked by sinuous ridges.

Cantaloupe cells are attributed to diapirism or interaction of solid-state convection with a dense overlying layer [7]). The greater relief and low scarps within the cells indicate a combination of sublimation erosion and convective overturn of a material considerably more viscous than Pluto's nitrogen ice. Carbon dioxide ice is highly viscous at Triton surface temperatures but markedly weaker than water ice within the subsurface, and has been spectroscopically identified on Triton, but is not widespread on Pluto [9]. The differing morphologies may thus be attributed to compositional differences between the terrains [10].

The etched plains on Triton [2] east of Leviathan Patera feature bear a physical resemblance in some locations to the plains northeast of Sputnik Planatia. These enclosed depressions on Triton are only a few hundred meters deep compared to the 2-4 km deep depressions on Pluto. Whether this relates to inherent layer thicknesses on the two bodies is unclear. The large walled plain of Ruach Planitia (which could be an analog to Piri Planatia on Pluto) is defined by a sinuous single inward facing scarp between 100 and 150 m high (depending on flanking terrains), but the surface of the plain appears to be gently domed ~150 m and in the center is approximately as high as surrounding terrains. The etched and pitted material in the center thus could be erosion rather than volcanic.

Both Triton and Pluto possess dramatic volcanic terrains. However, the kilometers high volcanic edifices (Wright and Piccard Mons [5]) have much more relief than the low volcanic plains of Cipango Planum [2] on Triton (Fig. 3), which the stereo DEM limits to <1.0 km relief. The most dramatic volcanic features of Triton include the Leviathan Patera caldera and chains of volcanic pits [2] extending to the northeast (Fig. 3), which more resemble basaltic rift zones such as Kilauea and have relief ≤1 km. The icy shells on both planets appear composed of viscous materials but the volcanic materials extruded on Triton may be more gas rich (given the abundance of pit chains) and significantly lower in viscosity (given the low relief and lack of edifices). Triton's smooth volcanic plains could be emplaced by "ash" fall rather than effusive flows.

Global topographic properties clearly reflect the geologic history of icy bodies. In contrast to Pluto [5], the limb and stereo topography for Triton is not reliable enough to assess regional topographic characteristics. The few limb profiles processed [8] and our limited stereo indicate that regional and global topographic variations on Triton are much lower than the ~6 km range observed on Pluto [4]. Part of this difference is related to the large and deep Sputnik Planitia (SP) basin, constructional volcanism (Wright and Piccard Mons) and elevated bladed terrains [5], none of which are observed on the resolved portions of Triton. However, the older lightly cratered etched plains flanking SP are relatively flat and undisturbed with a topographic range of ~2 km. These ancient terrains may be related to the etched plains of Triton and could reflect an ancient period when Pluto was more Triton-like.

**References:** [1] Hendrix, A. R. et al. (2019) *Astrobiology* 19(1), doi:10.1089/ast.2018.1955. [2] Croft, S. et al. (1995) *Neptune and Triton,* Univ. Arizona Press, pp. 879-948; [3] Prockter, L. et al., (2019) LPSC abstr.; Mitchell K. et al., (2019) LPSC abstr.; [4] Schenk et al., AGU abstract; [5] Schenk, P. et al., (2018), Icarus, 314, 400-413. [6] Hansen, C., et al., (1990), Science, 250, 421-424; [7] Schenk, P., and M. Jackson, (1993) Geology, 21, 299-302; [8] Thomas, P., (2000), Icarus, 148, 587-588; [9] Quirico, E. et al. (1999) *Icarus* 139, 159-178; [10] O'Hara, S., and Dombard, A.J. (2019) *LPSC L*, Abstract #2089.