PLUTO'S SPUTNIK BASIN AS A PEAK-RING BASIN: A COMPARATIVE STUDY. S.A. Moruzzi[1], J.C. Andrews-Hanna[1], P. Schenk[2], B.C. Johnson[3], W.B. McKinnon[4], [1]University of Arizona, Tucson, AZ (smoruzzi@email.arizona.edu), [2]Lunar and Planetary Institute/USRA, Houston, TX, [3]Purdue University, West Lafayette, IN, [4]Washington University in St. Louis, Saint Louis, MO.

Introduction: Pluto's Sputnik basin, a ~1650 km by 870 km wide, elliptical impact basin in Pluto's equatorial region [1], is a unique structure for the outer Solar System. Previous studies have compared the dimensions of Sputnik to large impact basins in the inner Solar System [2-4]. However, such basins are typically multiring structures, with two or more concentric asymmetric ring scarps surrounding a central depression. No such multiring structure has been previously documented for Sputnik Basin. Here, we show that the topography and morphology of Sputnik basin are consistent with a peak-ring or multiring structure similar to basins on the Moon, Mars and Mercury.

Sputnik basin is partially filled with an N_2 rich volatile deposit with a north-south trending chain of water-ice mountain blocks rising ~1.5 km above the fill, ~120 km from the western rim [1,2,5]. Previous studies have proposed that the chain of mountain blocks was emplaced in the N_2 ice deposit by either floating and then becoming grounded [1,2] or basal siding after fragmentation of the water ice crust during the basin-forming impact [6]. We instead interpret this chain of water-ice mountain blocks to be the exposed remnant of the inner ring of Sputnik basin. We compare the morphology and topography of Sputnik basin to 19 peak/multi-ring basins in the inner solar system. Where the basin floor is covered by N_2 ice, we use the convection cell patterns to constrain the topography of the basin floor. The interpretation of Sputnik as a peak-ring or multiring structure would have implications for basin compensation [7-9] and basin formation processes on icy outer Solar System bodies.

Methods: For topographic and morphologic comparison, we utilized a stereo Digital Elevation Model (DEM) [2,5] for Pluto, the LOLA DEM [10] for the lunar basins and the MOLA DEM [11] for martian basins (Fig. 1). Average radial profiles from the center of the each basin were scaled and compared to average radial profiles of Sputnik Basin. Sputnik basin was distorted to circularize the main basin rim prior to averaging.

For each basin, including Sputnik, we measured the diameters of the rings and the crustal thinning within the inner rings of the basins with respect to the background values [7,9, -12]. For Sputnik, we estimate the pre-fill basin depth based on the observed depth and estimated fill thickness, taking into account the degree of compensation expected for the load, and calculate the shell thinning for isostatic compensation of a water ice shell above a liquid water ocean, consistent with a model of the basin's formation [8]. These parameters were compared to the inner ring diameter of each basin. We then found the residuals for each basin relative to the linear fit for the tested parameters and tested whether Sputnik could be considered an outlier based on its residual, as well as using a Grubbs outlier test.

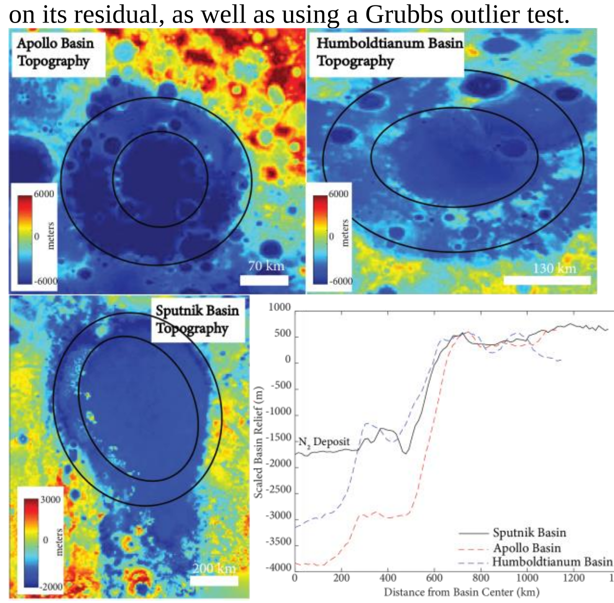

Figure 1: **Morphological and topographic comparison of Sputnik basin to Apollo and Humboldtianum basins. The Lunar basins have been scaled for relative comparison. All of the profiles have the same vertical exaggeration.**

The volatile deposit within Sputnik Basin consists of convecting N_2 ice with cells ranging from 5 km to 200 km wide [1, 2, 13]. The cell diameters are thought to scale with the thickness of the deposit. We used these cell diameters to probe the relief along the buried basin floor to evaluate the possibility of a submerged basin ring in the eastern half of the basin.

Results: We first note a qualitative similarity between profiles of Sputnik basin and lunar peak-ring basins. Of the lunar basins, Apollo and Humboldtianum (Fig. 1) provide comparatively similar topographic structures to Sputnik Basin, including a discontinuous inner ring of peaks at a consistent radial distance from the center. The relief of the putative inner ring of Sputnik is also comparable to the inner ring of multiring basins (e.g., the Inner Rook of Orientale), but no more than 2 rings can be identified in Sputnik. While some studies have identified an outer ring for the Hellas basin on Mars and an inner ring for the South Pole-Aitken basin on the Moon, Sputnik does not show a clear similarity to either of these basins except for in diameter and elongation. Sputnik basin's diameter exceeds the 582 km maximum diameter of peak ring basins on the Moon [14] and 320 km diameter on Mercury [15], but given the lower gravity, low heat flow, and thick shell relative to basin depth on Pluto, a larger transition diameter may be expected. Sputnik is elongated compared to the mostly circular peak-ring basins on the Moon. However, the small radius of Pluto makes the elongation of a large impact due to the curvature of the surface more likely [16].

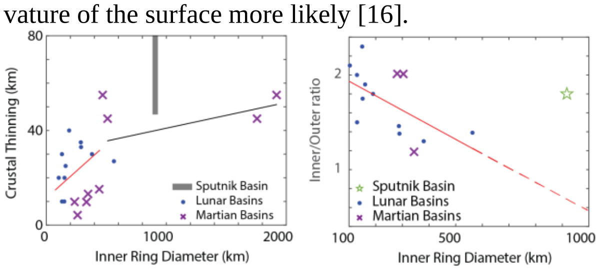

***Figure 2*: A) Crustal thinning vs Inner ring diameter comparison for all basins. Range for Sputnik basin is in grey. B) Ring ratio vs Inner ring diameter comparison for all basins.**

We compared the inner ring diameter for each basin with the crust/shell thinning beneath the interior of the inner ring (Fig. 2) [7,12]. The crustal thinning for martian and lunar basins increases with inner ring diameter, leveling-off at a diameter around 500-700 km, corresponding to the diameter at which the impacts excavate entirely through the crust [7]. A two-slope linear regression was fit with p-values of 0.32 and 0.51 respectively. Sputnik basin has a minimum residual that is only 0.98 standard deviations from the trendline, and fails the Grubbs test, so it is within the range of peak/multi-ring basins. By its position in the plot, we find that Sputnik lies closer to the continuation of the small basin trendline, unlike the larger martian and lunar basins that excavated completely through the crust, indicating that Sputnik did not fully excavate through the ice shell. Smaller peak-ring basins to exhibit both a wider spacing and more variability (a ratio of 1.79±0.28) , while the larger multiring basins are more tightly clustered at 1.38±0.06, similar to the characteristic ring spacing of 1.4 for multiring basin rings [17]. The ratio for the entire population of 1.75±0.3. The ring diameter ratio of Sputnik of 1.82 is within 1σ of the ratio for peak-ring basins and the population as a whole, but is larger than typical for multiring basins [4]. Thus, the ring ratio of Sputnik is more like a smaller peak-ring basin.

There is no clear trend in the comparison between inner ring diameter and relief of the inner ring relative to the surroundings, and a p-value of 0.65 suggests that these two parameters are uncorrelated. The relief of the putative inner ring of Sputnik on the western side of the basin is -2 km relative to the background elevation, within the 1-σ range of other basins of -1.21±1.37 km.

The peak ring of Sputnik is only exposed in the western half of the basin. We note that the N_2 convection cell sizes decrease near the mountain blocks on the western side as the deposit thins. Similarly, the convection cell sizes decrease on the eastern side as they approach where the continuation of the basin ring would be expected, and then no cells are found beyond this point [13]. This region of expected continuation of the putative inner ring also corresponds with a subtle inflection in the relief of the deposit. Future work will use the convection cell diameters to constrain the variation in deposit thickness with position in the basin to test the submerged peak-ring interpretation.

Conclusions: Our preliminary results show that Sputnik basin is topographically, morphologically, and statistically consistent with a peak ring basin. Sputnik basin shows that peak-ring basins can extend into the sizes where substantial elongation is predicted. As a peak ring basin, the diameter of the excavated material and any potential mascon [8,9,18] would be substantially smaller than if Sputnik were assumed to be analogous to basins such as Hellas on Mars. This structure would have implications for the inferred size of the impactor [8,19] as well as the potential for true polar wander driven by the basin. This interpretation has significant implications for our understanding of the formation of Sputnik [8] as well as peak-ring and multiring basins more generally.

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