MORPHOLOGY OF SMALL SHIELD EDIFICES AT IDUNN MONS, VENUS: IMPLICATIONS FOR THE VOLCANIC HISTORY OF A POTENTIALLY ACTIVE VOLCANO. N.P. Lang[1], J. McCarthy[1], and B.J. Thomson[2], [1]Department of Geology, Mercyhurst University, Erie, PA 16546 (nlang@mercyhurst.edu); [2]Department of Earth and Planetary Sciences, University of Tennessee, Knoxville (bthomso1@utk.edu).

Introduction: Idunn Mons (46.5°S, 215°E) is a ~200 km diameter large shield volcano that rises ~3 km above the surrounding terrain on the eastern edge of Imdr Regio on Venus. Erupted materials at this construct have predominantly manifested themselves as (a) extensive lava flows that radiate from the summit region and/or fractures on the flanks and (b) small shield edifices (herein referred to as small shields [e.g.,1]). The Visible and Infrared Thermal Imaging Spectrometer (VIRTIS) on Venus Express detected relatively high values of nightside thermal emissivity near 1 μm wavelength on flows on Idunn's eastern flank [2], suggesting this volcano may have been recently active [2-3]. This makes Idunn Mons an intriguing landform to examine in any future mission to Venus.

However, to maximize the return of any data collected for Idunn Mons via a future mission requires constraining stratigraphic relations as determined from the highest spatial resolution images currently available (i.e., Magellan SAR data) [e.g., 3]. Here, we use the morphologic properties of small shields exposed on this volcano's flanks to help determine gross stratigraphic relations. Our results provide a broad glimpse into the volcanic history of this potentially active volcano.

Approach: To determine morphologic properties of small shields on and around Idunn Mons, we followed the methods of [4-5], who each determined morphologic characteristics of shield edifies by measuring the basal radius and, if a summit pit is present (**Fig. 1**), determining the edifice's height. Edifice height (h) can be calculated by [4-5]:

$$h = \Delta x(\tan \theta) \quad (1)$$

where Δx is the displacement of the edifice's summit from the center of a circular outline and θ is the incidence angle, which ranges from 23° at ~50° S to 36° at 25° S [6]. The base of the edifice can be identified based on a quasi-circular change in backscatter; small shields on the distal flanks of Idunn Mons had distinctive bases whereas those on the upper flanks of the volcano were more difficult to discern (**Fig. 1**). Approximating edifices as spherical caps, height calculations from (1) can be used to calculate edifice volumes (v) [5]:

$$v = (\pi/3)(h^2)(3r - h) \quad (2)$$

where r is the basal radius of the edifice. We recognize the resulting calculations are likely an overestimate [e.g., 5] as the edifice shape is approximated, nor have we accounted for the presence of a summit pit, or taken into account any porosity of erupted material. However, the calculated values do provide a sense of perspective for the volume of material that has erupted to form the small shield edifice.

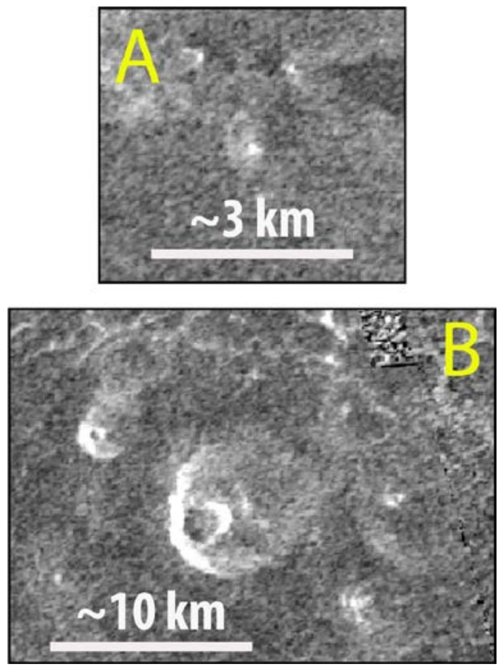

Figure 1. *Magellan SAR images of small shield volcanoes with summit pits that occur in conjunction with Idunn Mons. (A) Small shield that occurs on the upper flanks of Idunn Mons. (B) A cluster of small shields that occur on the eastern distal flanks of Idunn Mons. The base of the edifice in (A) is less distinct than the two largest edifices in (B). Summit pits are recognized by either a white dot (as in A) or as a circular depression (as for the two larger edifices in B).*

Results: Radii, height, and volume were calculated for 17 small shields on the upper and distal flanks of Idunn Mons (**Table 1**). **Figure 2** shows the properties of these edifices in relation to their distance from the Idunn Mons' summit. Although some scatter exists, there is an overall increase in all three properties moving away from the volcano's summit. Specifically, edifice bases on the distal flanks on the eastern side of the volcano have radii of ~1.5 km to ~3 km whereas edifices on the upper flanks of the volcano have basal radii of ~1 to ~1.5 km (**Fig. 2**). Interestingly, there is little difference in the erupted volume at the two locations, though the shields on the upper flanks mostly have smaller volumes.

Implications for Idunn Mons' volcanic evolution: The difference in small shield properties is noticeable and, although it could be due to smaller edifices being constructed on the upper flanks of Idunn Mons, the noticeable abundance of large outpourings of magma from the summit suggest these edifices could also be partially buried. The additional observation that edifices on the upper flanks have less distinct bases (i.e., more subtle radar backscatter changes) compared to those on the distal eastern flanks is consistent with the idea that upper flank shields are partially buried. This suggests multiple episodes of waxing and waning volcanic activity at this volcano where periods of volcanism that formed the small shields pre-dated at least some of the youngest eruptive episodes exposed at Idunn Mons.

Ultimately, the presence of small shields on the upper flanks of Idunn Mons is not surprising given the higher elevation of this volcano. The lower atmospheric pressure at higher elevations could facilitate slightly more explosive eruptions that result in cinder cone-like edifices on the upper flanks [7; see also 8]. Consequently, if our interpretation that small shields on the upper flanks of Idunn Mons have been at least partially buried is correct, then it is possible more of these smaller edifices formed here, but have been mostly to completely buried by subsequent volcanism.

References: [1] Guest et al. (1992) [2] Smrekar, S.E., et al. (2010) *Science*, p.1186785, doi: 10.1126/science.1186785. [3] D'Incecco, et al. (2017), *Planet Space Sci*, v. 136, p. 25-33; https://doi.org/10.1016/j.pss.2016.12.002. [4] Kreslavsky, M.A. and Head, J.W. (1999), *JGR*, 104, E8, 18,295-18,392. [5] Nypaver et al. (2018), *GSA Spec. Paper 538*, https://doi.org/10.1130/2018.2538(20). [6] Ford et al. (1993), *JPL Pubs*., 93-24. [7] Head, J.W. and Wilson, L. (1992), *JGR*, 97, E3, p. 3877-3903. [8] Mouginis-Mark, P.J. (2016) *Icarus*, 10.1016/Icarus.2016.05.022

Table 1. *Location and properties of the 17 small shields examined.*

Edifice #	Latitude	Longitude	Volume (km^3)	Radius (m)	Height (m)
1	-46.738	-140.641	1.88	2900	467
2	-46.701	-140.716	1.00	1500	488
3	-46.818	-140.824	0.03	700	127
4	-46.409	-140.384	1.83	1850	594
5	-46.717	-141.175	0.15	1100	212
6	-46.651	-141.24	0.05	1000	127
7	-46.326	-141.588	0.02	700	106
8	-46.04	-140.138	0.02	590	106
9	-46.007	-140.028	0.37	1650	276
10	-45.861	-140.398	1.09	2500	382
11	-45.787	-140.177	1.56	1750	565
12	-45.755	-140.264	0.00	800	21
13	-45.742	-140.615	4.68	2450	828
14	-45.633	-140.405	0.20	1000	263
15	-45.511	-140.291	4.46	2350	828
16	-45.312	-140.28	8.26	2825	1,029
17	-44.997	-143.746	0.18	950	255

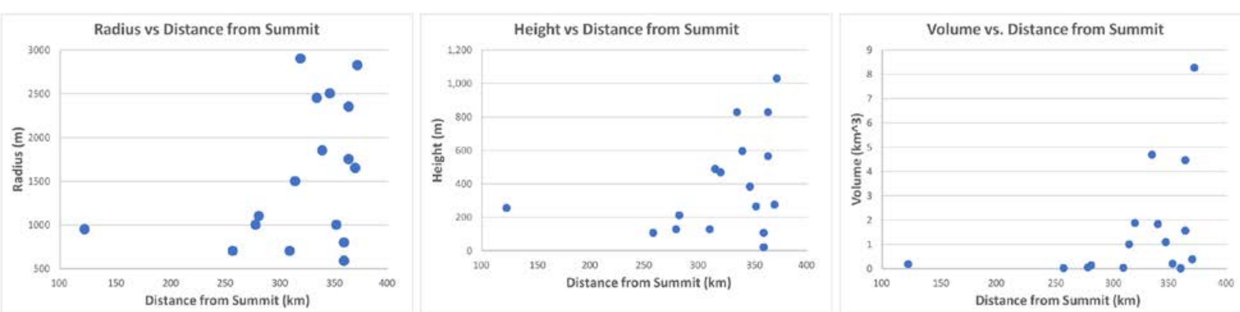

Figure 2. *Graphs summarizing the morphologic properties of the 17 measured small shields at Idunn Mons.*