ANALYSES OF MID-SIZED VENUSIAN VOLCANOES COVERED BY STEREO IMAGES. J. J. Knicely, and R. R. Herrick, Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK 99775-7320, jknicely@alaska.edu, rrherrick@alaska.edu.

Introduction: The lithosphere of Venus and its evolution through time are poorly understood. Comparing the shapes of Venusian volcanic constructs to their counterparts on Earth can provide insight into the eruptive conditions and lithospheric state when the volcano formed. Previous efforts have focused primarily on the largest Venusian volcanoes (diameter of flows >300 km), as the Magellan altimetry data has a resolution and footprint size of 10-20 km. Here we use Magellan stereo-derived topography, with a horizontal resolution of 1-2 km and vertical resolution of 50-80 m [1] to study mid-sized (50-300 km) Venusian volcanic constructs.

Methods: We extracted a list of all volcanoes with designations IV (intermediate volcano) or LV (large volcano) covered by stereo imagery with diameters greater than 50 km from the Brown Planetary Tabulated Magellan Venus Volcanic Feature Catalog [2]. Profiles of each volcano were extracted from Magellan stereo-derived topography [1] or generated via manual tie point selection with Magellan opposite-look stereo images. These were used to extract quantitative information about the volcanic constructs (e.g. relief, base height, slope). We searched for any morphologic similarities between this subset of volcanoes and volcanic features on Earth. We classified the constructs based on the observed morphology and topography, and then searched for patterns among ancillary data related to each construct including distance to other features such as tesserae and chasmata, relief, base height, crustal thickness, and mantle load distribution [3].

Classifications: We have developed a classification scheme with 5 broad categories: volcano-to-corona-transition (VtCt), resurgent, volcano (fissure, shield, and "stratovolcano"), stellate fracture center (SFC), and corona. We selected a total of 23 volcanoes. Of these, 17 are ≤300 km in diameter. The largest is Pavlova corona with a diameter of 760 km which contains a stellate fracture center 180x150 km. These are described below and in Figures 1-2.

VtCt. The VtCt appears to be a gradational step between a volcano and a corona, where a volcano appears to have topography and some morphologic features consistent with corona formation processes. These typically have i) nearly flat flanks or a circumferential depression on the flanks, ii) radial lava flows that predate any deformation of the flanks, iii) circumferential linea or fractures on the flanks near the caldera, iv) radial linea extending from the caldera, and v) caldera at or below the elevation of the surrounding topography (i.e. away from the flanks). Four have been given this designation with three more that possibly fit this category. An example is shown in Figure 1 and another is located at 13.5°N 78.0°E.

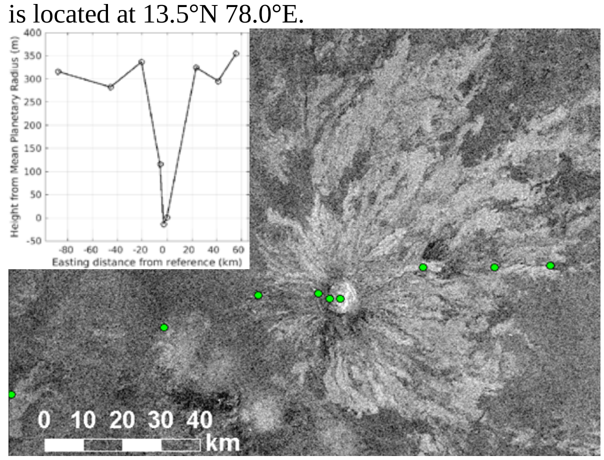

Figure 1. Magellan SAR image of example VtCt Sephira Mons at 43.1°S 28.0°E. The topographic profile created from manual tie points indicates a nearly flat profile (recall estimated error is 50-80 m) with an interior depression of ~300 m. The radial lava flows indicate this construct initially had positive relief. Circumferential linea surround the caldera. Green dots represent the tie point locations which are shown as black circles in the inset.

Resurgent. Three resurgent domes have been identified with one more possible resurgent dome and one possible resurgent block. These are all within coronae. Resurgent domes and blocks on Earth are confined to the interiors of calderas. Leading causes include the introduction of new magma or the concentration of magma from peripheral dikes to a central magma chamber [5, 6], though more possible causes exist. Resurgent domes are typified by i) domed structure within the caldera rim, ii) central, linear, graben-like rift, iii) circumferential or near-circumferential fractures along the base of uplift, and iv) possible volcanism at the base of upward doming and at the central rift. Resurgent blocks have i) a raised piston-like block with ii) possible volcanism around its periphery [5, 6]. The presence of these structures within coronae suggests the corona rim as a proxy for the caldera rim. An example is within Didilia corona, shown in figure 2, and another is located at Anala Mons, 11°N 14.5°E.

Volcano. We identified 8 volcanoes; 2 shield volcanoes typified by a shallowing of its slope as the summit is approached, up to 3 fissure volcanoes typified by an elongated fissure vent, and up to 3 "stratovolcanoes" typified by a steepening of the slope towards the summit. Two of the 3 fissure volcanoes appear to be transitioning to a more centralized conduit, and 2 of the 3 "stratovolcanoes" share characteristics of the VtCt class, but cannot be definitively placed within that category. Example fissure, shield, and "strato-" volcanoes are located at 7.0°S 199.5°E, 57.6°S 16.0°E, and 31.6°S 228.0°E.

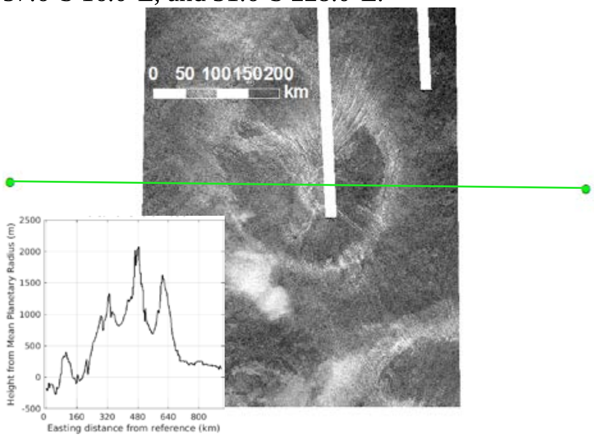

Figure 2. Magellan SAR image of example resurgent dome within Didilia corona at 18.5°N 38.0°E. Topography indicates a domal rise that reaches 500 m above the surrounding corona rim along with a graben at its center approximately 200 m deep. The green line shows the path of the profile extracted from the stereo-derived DEMs.

SFC. We identified 4 stellate fracture centers, two of which were within coronae and one that was formerly identified as a large volcano. An example is located at 63.0°N 88.0°E.

Corona. There is a single type 1 corona identified by [2] as a large volcano located at 28.0°N 65.0°E [4].

Results & Interpretation: Examination of stereo-derived DEMs and manual profiles of these volcanic constructs has revealed topography that does not correlate with what one might expect from looking at the Magellan images (e.g., Figure 1). The topographic data indicate up to several hundred meters of vertical post-emplacement deformation of several volcanoes. This vertical movement occurs at scales large for terrestrial calderas, but previously unobserved at these scales for Venusian constructs. The lateral extent of the deformed regions is small compared to typical coronae, though the size of the volcanic construct is within the bounds of the smallest coronae previously identified [4].

Resurgent Domes. The diameter of the resurgent dome and the encompassing caldera provide an estimate of the diameter of the underlying magma body [7]. The resurgent domes identified here have diameters of 66, 71, 130x100,and 173 km, with coronae rim sizes (which is used as a proxy for the caldera rim) 450, 204, 210x185, and 359x250 km respectively. This suggests magma bodies on the order of several 10's to >100 km in diameter. Such large magma bodies are difficult to explain, especially if the magma body is considered a sphere or vertical cylinder. The proclivity of magma to form sill-like magma bodies on Venus may be responsible and provides the best fit to the observed deformation patterns of Anala Mons (one of the constructs examined here) and other large volcanic edifices of Venus [8, 9].

VtCt. The 4 VtCts identified have diameters of 55-90 km, base heights ranging from 0.7-1.4 km, and crustal thicknesses of 11-15.4 km. Including the 3 possible VtCt's changes these to diameters of 55-160 km, base heights of 0.2-1.4 km, and crustal thicknesses of 11-16.1 km. These structures appear to have been constructed as a volcano followed by a collapse of the center of the edifice. These formed at similar to slightly higher base heights and at lower crustal thicknesses as compared to the resurgent domes and SFCs within coronae studied here, except for the possible resurgent block corona which formed at a lower base height of 0 km and a lower crustal thickness of 12 km. I interpret these as an intermediate step in a process in which intermediate volcanoes can become coronae by a loss of support in which the center of the edifice collapses. Alternatively, the process at work could be related to caldera collapse and be independent of coronae formation. Of the VtCts, 2 have what appear to be nested calderas, which are often associated with the draining of the magma chamber of basaltic shield volcano calderas [10].

Acknowledgements: This work was funded by PG&G grant NNX14AM84G.

References: [1] Herrick, R. R. et al. (2012) *EOS*, 93. [2] Crumpler, L. S. et al. (1997) *Venus II*. [3] James, P. B. et al. (2013) *JGR*. 118. [4] Stofan, E. R. et al. (2001) *GRL*, 28. [5] Accocella, V. et al. (2001) *Jrnl of Volc and Geo Res*, 111. [6] Saunders, S. J. (2004) *Bull. Volcanol.* 67. [7] Wood, C. A. (1984) *JGR*, 89. [8] K. R. V. et al. (2011) *LPSC XLII*, Abstract #2712. [9] McGovern, P. J. et al. (2014) *Geology*, 42. [10] Krassilnikov, A. S. et al. (2004) *LPSC XXXV*, Abstract #1531.