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QUANTIFYING SHAPES OF VOLCANOES ON VENUS: J. B. Garvin, NASA/Goddard, Code 921, Geodynamics, Greenbelt, MD 20771 USA

A large population of discrete volcanic edifices on Venus has been identified and catalogued by means of Magellan SAR images, and an extensive database describing thousands of such features is in final preparation [1-4]. Those volcanoes categorized by Head and colleagues [4] as *Intermediate to Large* in scale, while relatively small in number (~400), nonetheless constitute a significant volumetric component (~ 13×10^6 km^3) of the total apparent crustal volume of Venus. For this reason, we have focused attention on the morphometry of a representative suite of the larger edifices on Venus, and in particular on ways of constraining the eruptive histories of these possibly geologically youthful landforms. Our approach has been to determine a series of reproducible morphometric parameters for as many of the discrete volcanoes on Venus that have an obvious expression within the global altimetry data acquired by Magellan. In addition, we have attempted to objectively and systematically define the mathematical essence of the shapes of these larger volcanoes using a polynomial cross-section approximation involving only parameters easily measured from digital topography, as well as with simple surface cylindrical harmonic expansions. The goal is to reduce the topological complexities of the larger edifices to a few simple parameters which can then be related to similar expressions for well-studied terrestrial and martian features..

Building on the results of a first-order morphometric comparison of Icelandic lava shields and selected venusian edifices [3], we have analyzed over 50 volcanoes on Venus, from which 7 have been chosen as representative end-member varieties: Tepev, Maat, Sapas, Sif, Gula, feature at 10.5N, 274E (V29 Quad), and a volcano at 46S, 215E (V51 Quad). The **Table** below lists some of the first order morphometric characteristics of these features as derived from Magellan altimetry data, polynomial approximations, and cylindrical harmonics. For comparison, classic terrestrial basaltic shields are also listed.

Volc. Name	D(km)	H(km)	Vol. (km^3)	H/D	shape n_x	V/D (km^2)	Flank Slope	Peak Amp.
Tepev	196	5.7	100000	0.030	2.8	508	3.3	800
Sapas	231	2.3	62000	0.010	3.6	267	1.1	410
V29 V	270	1.6	44000	0.006	1.9	161	0.7	1400
Sif	259	2.0	32000	0.008	0.9	124	0.9	520
Gula	233	2.5	41000	0.011	1.2	172	1.2	700
V51 V	186	2.4	30000	0.013	1.7	161	1.5	1280
Maat	312	7.5	355000	0.024	3.2	1136	2.7	740
Skjald	11	0.6	13	0.060	0.6	1.2	6.5	81
M.Loa	51	2.9	1620	0.060	0.7	32	6.5	210

The last two entries, *Skjald.* and *M. Loa* are representative of classical terrestrial shields at two different length scales; the M. Loa data describe only the subaerial component of the volcano. **"Peak Amp."** describes, in part, the shapes of all of the volcanoes in terms of the *degree one amplitudes* (in meters) of the nine-term cylindrical harmonic spectrum (CHS) for each feature (i.e., a 9x5 model rendered as a plot of amplitude vs degree).

The classic Icelandic lava shield Skjaldbreidur diplays a degree 1 amplitude of only 81 m; all the other terms (degrees 2-9) have amplitudes less than or equal to 10. The spectra of Sif Mons displays an RMS variance of only 0.46 relative to that for Skjaldbreidur. Of the 50 volcanoes on Venus whose shapes we modelled using cylindrical harmonic expansions, only Sif and Gula displayed RMS variances (relative to that of *Skjald.*) less than 1.0. The best fitting power laws to the cylindrical harmonic spectra for the Venus and Earth volcanoes considered also illustrate the fundamental differences between most of the typical large-scale volcanoes on Venus and the lava shields of Earth. Again, only Sif and Gula Mons appear to display cylindrical harmonic spectra that resemble those of Earth shields. The Volumes listed in the Table were all computed from the CHS data and not directly from the Magellan GxDR altimetry. Variances in volume of up to 15% were observed when CHS results were compared with those measured from the altimetry directly. However, we believe the CHS-based Volume estimates are more reliable and objective, and they potentially permit analytical computation of volcano volumes independent of the initial data.

Our investigation of the shapes of volcanoes on Venus has illustrated several points. While there is little question that small "shield-field" volcanoes resemble monogenetic terrestrial basaltic volcanoes (and most especially lava shields [1,4,6,7]), the edifices larger than about 60 km that have been described in the literature as "shields" [1] do not in general display shapes that are shield-like in a morphometric sense [7]. Indeed, our volcano scaling studies have shown that while larger volcanoes on Mars do resemble scaled-up terrestrial basaltic shields (i.e., with basal diameters in the 500-800 km range), the larger so-called "shields" of Venus are noticeably more dome-like in cross-section (see n_X column in Table; values above ~ 1.5 tend to be more convex), and less voluminous. Terrestrial shields have edifice volumes which scale with basal diameter to the power of 2.9 to 3.2, while those on Venus scale at a power of 2.7. Only Maat and Tepev are close to the terrestrial shield volcano volume scaling trend. If volcanoes in the Solar System displaying terrestrial shield-like topography are effusive, basaltic varieties, then only a few of the larger venusian varieties that have been classified as such are likely to have been formed with eruptive histories and volume eruption rate patterns of landforms like Mauna Loa or Skjaldbreidur. The shape variability of the larger venusian edifices suggests a wide variation in the episodic eruption rate, and also points to a dominantly summit-area eruptive history. Reconciling the shield-like pattern of SAR backscatter features observed by Magellan at high resolution with the volcano topographic data, which does not indicate a shield-like morphometry, remains a problem we wish to address in our ongoing studies. {We acknowledge the support of the VDAP Program, RTOP 889-62-10-41, for this work; special thanks to S. Baloga for his support and to Jim Frawley}.

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