TARGETING THE PLAINS OF VENUS FROM ORBIT. V. L Sharpton, Lunar and Planetary Institute (3600 Bay Area Blvd., Houston, TX 77058; sharpton@lpi.usra.edu).

Session: From orbit.

Target: The lowland plains comprising >80% of the surface area of Venus.

Science Goal(s): II.A.1, II.A.3, II.A.4, II.B.2, II.B.3, II.B.5, II.B.6.

Discussion: Volcanic plains units of various types encompass at least 80% of the surface of Venus. Though devoid of topographic grandeur and, therefore often overlooked, these plains units house a spectacular array of volcanic, tectonic, and impact features. Here I propose that essentially global acquisition of high-resolution topography and imagery is required to significantly improve knowledge of these plains features, settle the continuing global stratigraphy debate, and resolve how the only other accessible Earth-sized planet has evolved.

Impact craters [Goals II.A.1, II.A.3, II.B.2, II.B.3, II.B.6]. The quasi-random distribution of impact craters and the small number that have been conspicuously modified from the outside by plains-forming volcanism have led some to propose that Venus was catastrophically resurfaced around 725±375 Ma with little volcanism since [1]. Challenges, however, hinge on interpretations of certain morphological characteristics of impact craters that could indicate they have been modified from within by plains-forming volcanism [2,3]. The proportion of the global crater population that predates volcanism and subsequent tectonics, while poorly constrained, is vitally important for understanding the age(s) and abruptness of any plains-forming epoch(s). Improved image and topographic data are required to measure stratigraphic and morphometric relationships and resolve this issue.

The rocks exposed in central peaks of impact craters originate from depths equivalent to ~6% of rim diameter [4]. Consequently, craters are effective windows into the subsurface of Venus. For instance, the 63-km Aglaonice crater located in Lavinia Planitia, exposes rocks in its central peak complex that were originally ~4 km below the preimpact surface. Analysis of high resolution imagery and topography covering Martian craters [5] has shown that some central peaks exhibit coherent structural trends indicative of lithology. Consequently, improved images and topography over Venusian craters could provide new constraints on individual flow thicknesses of plains forming volcanism.

Volcanic features [Goals II.A.1, II.A.3, II.A.4, II.B.2, II.B.3, II.B.5]. Plains units are also home to a suite of volcanic features unrivaled in its diversity, size range, and sheer numbers [6]. This includes steep-sided domes, hundreds of shield fields each containing dozens of individual sources, isolated volcanoes, coronae, collapse features and regionally extensive lava channels and flows. The inferred viscosity range of plains-forming lavas, therefore, is immense, ranging from the extremely fluid flows (i.e., channel formers), to viscous, possibly felsic lavas of steep-sided domes [7]. Extremely low viscosities require exotic, possibly carbonate rich lavas [8]; high viscosity (if felsic) compositions, are known to carry enrichments of heat-generating elements. Unfortunately, the coarse resolution, low sensitivity, and variable viewing geometry of Magellan images and topography do not allow reliable constraints on rheologies, flow rates, and eruption durations to be derived in most cases. Improving constraints on the rates and styles of volcanism within the plains would lend valuable insights into the evolution of Venus's internal heat budget and the transition from thin-lid to thick-lid tectonic regimes.

Compressional features [Goals II.A.1, II.A.3, II.A.4, II.B.3]. Wrinkle ridges deform many plains units and have been taken to be an early global stratigraphic marker that limits subsequent volcanism to a minimum [e.g. 9]. Others [e.g. 10], propose that the plains have been built up by lavas erupted in a number of different styles, each occurring throughout that portion of Venus's history exposed at the surface. This two-decade-long debate is central to understanding how Venus has evolved but it is clear that it cannot be resolved with the currently available data.

Subtle backscatter variations within many ridged plains units indicate that some plains volcanism continued well after local ridge deformation ended. Furthermore, many volcanic sources show little, if any, evidence of tectonic modification. However, analyses are severely hampered by poor and variable resolution. Improved spatial and radiometric resolution of radar images and considerably improved topographic data are required to reliably determine the volumetric significance of post-ridge volcanism and improve abilities to construct the complex regional stratigraphy of ridged plains.

Data Quality Considerations: Acquisition of high-resolution data from orbit at Venus requires synthetic aperature radar (SAR) approaches.

Image data. SAR image quality is affected by spatial resolution, radiometric resolution (signal/noise), incidence angle (θi), and SAR frequency. To resolve and interpret the small scale features needed to meet the goals above, all these characteristics have to be considered and balanced against power, data storage, and upload rate considerations.

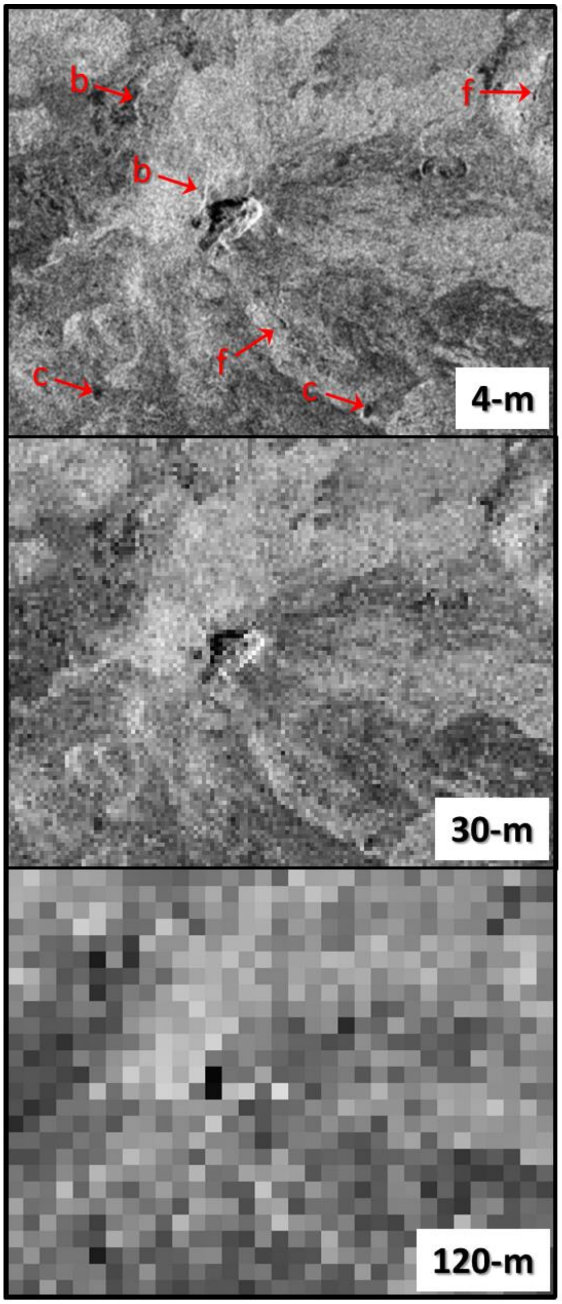

Fig. 1. Synthetic images of a 4-km wide region on Kileaua's East Rift Zone, showing Pu'u O'o crater and associated volcanic features. Look direction is from the left; incidence angle is ~44 degrees. Bottom frame approximates Magellan quality data, although the technique used to reduce resolution dramatically dampens noise and, in effect, improves the NESZ compared to Magellan data. Derived from RADARSAT data (C-band).

SAR frequency should be selected to minimize atmospheric interference and facilitate comparison either with existing Magellan data or terrestrial SAR data. These properties would favor either C-band (4-8) GHz) or S-band (specifically 2.385 GHz for Magellan).

Fig. 1 shows 30-m spatial resolution is sufficient to detect and characterize small flows, lava pools, tephra occurrences, etc. Improving spatial resolution to ~5 m, allows precise characterization of flow boundaries (b), fissures and channels (f) and small cones [11]. To avoid layover and shadowing, incidence angles should be chosen in the range of 45° to 25° and should be constant to facilitate comparisons over large latitude ranges. For either C- or S-band, the noise equivalent σ0 (NESZ) should be sufficiently low that normalized backscatter coefficients (σ0) from smooth, low reflectivity surfaces are resolvable. Assuming terrestrial playa surfaces are a reasonable σ0 floor above which all conceivable Venusian surface units would reside, NESZ(θi=25) ≤ -17dB and NESZ(θi=45) ≤ -27dB [12].

Topographic data. Surface heights can be constrained by three radar techniques: nadir-looking altimeters, stereogrammetry, or interferometry. To meet the goals related to plains formation, topographic data should have horizontal resolution (posting spacing) no greater than 500 m for regional-global assessments and ideally better than 50 m for local feature characterization. Vertical precision better than 50 m for reconnaissance data and 5 m for local analyses seems sufficient based on terrestrial and lunar studies. In both cases, topography should be geodetically controlled to maximize science returns.

Conclusion: Constraining the resurfacing history of Venus is central to understanding how Earth-sized planets evolve and whether or not their evolutionary pathways lead to habitability. This 'super goal' can only be adequately addressed if broad coverage is added to the implementation strategies of any future mapping campaigns to Venus.

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