VENUSIAN STEEP-SIDED DOMES: ESSENTIAL EXPLORATION TARGETS FOR CONSTRAINING THE RANGE OF VOLCANIC EMPLACEMENT CONDITIONS. Lynnae C. Quick[1,2], Lori S. Glaze[1], Steve M. Baloga[3], [1]NASA Goddard Space Flight Center (8800 Greenbelt Rd., Greenbelt, MD 20771, Lynnae.C.Quick@nasa.gov, Lori.S.Glaze@nasa.gov), [2]Oak Ridge Associated Universities, [3]Proxemy Research (20528 Farcroft Lane, Laytonsville, MD 20882, steve@proxemy.com).

Because volcanism is a means by which material from a planet's interior can be brought to its surface, volcanic processes can serve as clues into the internal structures and past histories of planets. Further, the rheology and dynamics of lava flows tell us a great deal about planetary surface conditions, while their chemistry and composition offer insights into conditions in the subsurface where they formed. A more comprehensive understanding of Venus volcanism would therefore help answer questions of why and when the evolutionary paths of Venus and Earth diverged. Here, we propose Venus' enigmatic, steep-sided, or 'pancake' domes as important exploration targets. Figure 1, below, shows a Magellan radar image and topography for such a dome.

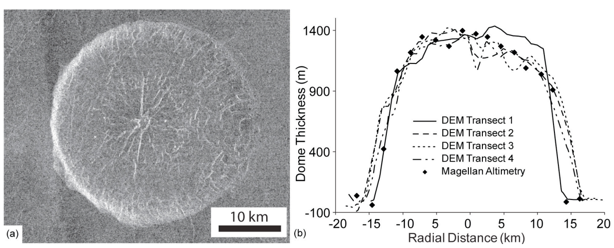

Figure 1. (a) Magellan image of a typical steep-sided dome in the Rusalka Planitia at 3°S, 151°E. (b) Topographic data for the dome shown in (a) with ~20x vertical exaggeration. The four transects depict topography from a digital elevation model generated from stereo Magellan images [1].

Session: From Orbit

Target: Our targets include domes in Venus' eastern hemisphere between 4 and 38°N and 9 and 70°E, and between 26 and 35°S and 70-100°E, as well as a cluster of domes east of Alpha Regio at 30°S, 11.5° E [1] (Fig. 2). [1] previously identified domes in these regions as domes for which we do not have complete stereo coverage or whose individual volume measurements may be tenuous due to their overlap with adjacent domes (Fig. 2).

Science Goal(s): Comprehensive 3-dimensional topography can be used with lava emplacement models to develop quantitative inferences about dome emplacement conditions (e.g., duration of supply, viscosity, volumetric flow rate). For Venus domes, the accuracy and precision of such constraints is completely limited by the existing dimensional data. The investigations we suggest here involve employing high-resolution imaging and topography to better assess the composition and emplacement conditions of steep-sided domes.

Numerous quantitative issues such as the nature and duration of lava supply, how long the conduit remained open and capable of supplying lava, and the role of rigid crust in influencing flow and final morphology all have implications for subsurface magma ascent and local surface stress conditions [2]. Placing stronger constraints on volumetric eruption rates will lead to a better understanding of the subsurface magmatic plumbing systems beneath these domes, and in doing so, could provide answers to many of these questions. As a result, these studies would greatly expand our knowledge of the volcanic and lithospheric history of Venus.

The questions that would be answered by carrying out these suggested observations are related to investigations II.A.1, II.B.3, and III.A.2 of the Goals, Objectives, and Investigations for Venus Exploration.

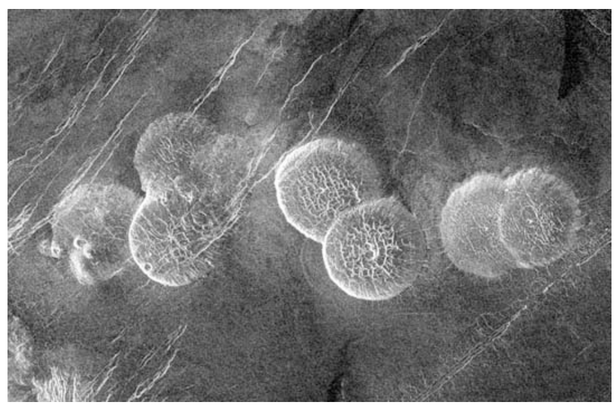

Figure 2. A chain of domes located to the southeast of Alpha Regio, all of which are located in overlapping clusters. Each dome is approximately 26 km in diameter [1,3].

Discussion: 175 steep-sided domes have been identified on Venus, with diameters ranging from 19-94 km [3-4]. These domes are thought to be volcanic in origin [5], having formed by the flow of a viscous fluid (i.e., lava) onto the surface.

Uncertainties in emplacement duration and lava rheology have made it difficult to place compositional constraints on the domes. Consequently, despite studies by several investigators, a significant conundrum concerning the composition of Venus' steep-sided domes still exists: higher-viscosity lavas (i.e. andesites or rhyolites) are implied by the need to sustain extremely thick flows (1-4 km) [5], while lower-viscosity lavas (i.e. basalts) are necessary to provide the relatively smooth upper surfaces that have been observed on the domes [4]. Further, because more evolved magmas like rhyolites and andesites have high water contents, while basalts are relatively depleted in water, the composition of Venus' domes could shed light on the water content of the planet. Silicic domes would imply that more evolved magmas existed on Venus, that the venusian crust has had an intricate history, and that, the amount of water in the mantle may have been very similar to that in Earth's mantle (cf. [6-7]).

Magellan's Synthetic Aperture Radar (SAR) had ~100 m spatial resolution with 75 m/pixel sampling. The Magellan Altimeter had along-track spacing of a few kilometers, at best, and vertical precisions of ~100 m. While topography derived from Magellan stereo images provides better spatial resolution than the altimetry, the vertical precisions are comparable. Accurate estimates of volumetric eruption rates for these domes will require higher resolution imagery than that provided by the Magellan spacecraft. In particular, much higher spatial resolution images are required to better constrain surface roughness characteristics and to understand how surface morphology may relate to lava composition and/or volume eruption rate. In addition, very high spatial resolution relative topography is required to constrain the detailed shapes of the dome surfaces, particularly to characterize the shapes of the steep dome margins. Topography derived from stereo SAR or Interferometric SAR (InSAR) is preferred for these analyses with spatial resolution of 10 – 30 m, and vertical precision of ~10 m.

Radar operating at these heightened resolutions and mounted to an orbiting spacecraft would return very detailed images of the pancake domes from which volumetric eruption rates could be deduced. From these rates, composition, rheology, and local surface and subsurface conditions could then be inferred. These details would provide further insights into Venus' geological evolution and would further illuminate historical and present-day commonalities and differences between Venus and Earth.

References: [1] Gleason, A.L. (2008) Masters Thesis, UAF. [2] Glaze, L.S., et al. (2012) 43rd LPSC, Abstract #1074. [3] Pavri, B., et al. (1992) JGR 97, 13,445-13,478. [4] Stofan, E.R., et al. (2000) JGR 105(E11), 26,757-26,771. [5] Head, J.W., et al. (1991) Science 252 (5003), 276-288. [6] Campbell, I.H. & Taylor, S.R. (1983) GRL 10, 1061-1064. [7] Bridges, N. T. (1997) JGR 102, 9243-9255.