STEEP-SIDED DOMES ON VENUS: CHARACTERISTICS AND IMPLICATIONS FOR COMPOSITION AND ERUPTION CONDITIONS. Betina Pavri[1], Brennan Klose[2], and James W. Head[1]. [1]Department of Geological Sciences, Brown University, Providence RI 02912; [2]Harvard-Smithsonian Center for Astrophysics, Cambridge MA 02138.

Introduction: The majority of volcanic features observed on Venus so far are interpreted to represent basaltic volcanism,[1-3] although more silic compositions are possible in the Venus environment.[4] Venera lander chemical analyses support a basaltic composition for all landing sites[5] except Venera 8, which is interpreted as an intermediate to silicic composition[6]. Magellan has revealed several clusters of distinctive, steep-sided volcanic domes[3] similar in morphology to terrestrial domes with intermediate to silicic compositions and higher effective viscosities[7]. Here we characterize in detail the morphology of one of a set of seven steep-sided domes 150 km southeast of Alpha Regio, compare it to terrestrial domes, and discuss implications for emplacement mechanisms and composition.

Description: The E-W chain of seven circular volcanic domes[3] rises amid a smooth, radar-dark plain at 30°S, 11 - 13°E. The domes are each ~25 km in diameter, almost circular in plan, and several have been estimated to be between 0.5 and 1.5 km high. Each dome overlaps or is overlapped by at least one other dome. The four eastern domes have sharper, more circular outlines, while the boundaries of the three western ones are diffuse, marked by craters, lava flows, and small satellite vents. We focus on one of the eastern domes in order to classify the major characteristics of dome morphology and to assess the eruption conditions which create that morphology (Fig. 1).

Radar backscatter patterns show that the dome has steep sides and an almost flat top. The flat summit occupies 80 - 85% of the dome radius. Altimetry and illumination geometry indicate that the dome is 0.5 - 1.5 km high and that the exterior slopes average 2 - 2.5 km in width and have slopes of 15 - 30°. This dome is much wider, higher, and flatter on top than the small shield volcanoes of probable basaltic composition that are so common on Venus.[8]

Several classes of **structures** are observed on this dome: 1) **fractures**, narrow, bright lineaments < 300 m wide; 2) **fissures**, paired bright and dark lines 300 m to 1 km across; and 3) flat-bottomed **troughs**, 0.5-1 km across. These structures and their distribution define several **units** on the domes. **Fissured flanks**, characterized by radar bright material and radial fractures and fissures ~5 km long, and spaced 0.5 - 2 km apart, form the outermost unit of the dome. The **dark annulus** occurs just inside the fissured flanks. Several subdued concentric and radial structures < 1 km wide make up the annulus, which is 2 - 3 km wide. The annulus grades on the outside into the fissured flanks, and on the inside into the **polygonal fractured zone.** This zone is 20 km in diameter and takes up most of the dome's top. A network of radial and concentric fissures and troughs characterize this zone, breaking the surface into polygonal pieces 1 to 3 km in size. We interpret the fractures and fissures as cracks, and the troughs as extensional graben; the radial array of fractures and fissures on the flanks suggests outward spreading. The graben and complex polygonal cracks around the summit may be due to distributed extension linked to expansion and/or subsidence. Two **summit pits**, 2 km and 3 km across, occur in the center of the dome. The pits are interpreted to be volcanic because of their small size and central location. Dark material with bright streaks, probably talus, lies in the crater interiors. Exterior deposits have not confidently been identified around the two pits, so it is uncertain whether the craters formed explosively -- from the venting of gases, for example -- or from collapse.

There is a sharp, well-defined contact between the dome and the surrounding plains. In the radar-dark plain east of the dome, radial troughs, fissures and fractures 1 - 3 km long and about 3 km apart are seen. Out of seventeen cracks in the plains, six are coincident with radial flank fractures. The flank fractures are more closely spaced than those in the plains, so such alignments may be fortuitous.

Interpretation: This dome shares many characteristics - steep sides, flat top, surrounding talus slopes - with terrestrial dacitic and rhyolitic domes (Fig 2a).[7] We tentatively interpret the morphology of this dome to be the result of dome growth like that observed for these types of domes[9,10].

Observations of terrestrial domes indicate that when viscous magma is extruded onto the surface, the outer crust cools quickly to form a brittle carapace. Talus forms on the steep faces of the growing dome. As the dome swells, the cooled crust cracks and expands to allow outward growth. The margins of the dome compress and break into blocks that thrust over each other, producing ogive-like ridges of the dome on the surface and a ramp-like structure in the interior. The concentric fissures on the Venusian dark annulus resemble these synclines between pressure ridges observed on terrestrial domes. Dome growth models for terrestrial lava domes[11,12] support this interpretation. Circumferential expansion of the dome is interpreted to create the radial fractures found on the outer slopes. The polygonal fracture pattern could result from either of two processes, upward growth or subsidence. The radial cracks in the plains are not presently understood.

Venus' steep-sided domes are larger than most terrestrial viscous domes - Earth's are mostly less than 10 km in diameter - and appear to be lower in relation to their diameter and more symmetrical. The anomalous shapes of the Venusian domes may be due to Venus' high surface temperature, which would tend to slow cooling and lengthen solidification times for all lavas, perhaps resulting in broader, flatter extrusive edifices.

Modeling of Eruptions: Lava domes have been modeled with theory and experiment.[11-13] Huppert *et al's* model has been applied to the domes of Alpha Regio in an attempt to assess viscosities and eruption rates. Viscosity and effusion rate are crucial in determining flow shape, and a range of viscosities (10^7-10^{12} poise) and effusion rates (10-100,000 m^3/s) was explored. The volume of the domes - about 500 km^3 each - allows an estimation of eruption duration for each effusion rate. Effusion rate and eruption duration give height and radius for a flow of given viscosity. We find that in general the model cannot precisely match the observed dimensions of the Alpha Regio domes, prohibiting precise estimation of viscosity and effusion rates. However, the best fits are obtained for high values of viscosity, 10^{10} - 10^{12} poise, coupled with effusion rates of 1,000-10,000 m^3/s. Such viscosities are most consistent with rhyolite or dacite. Effusion rates >1,000 m^3/s are higher than found for non-explosive silicic eruptions on Earth and are more similar to basaltic eruptions. Fig. 2 shows the profile of a modeled dome. The steep wall of the dome is ~1000 m high, consistent with the dome heights calculated from Magellan's viewing geometry.

Conclusions: The characteristics of these steep-sided domes on Venus are consistent with magmas with high effective viscosity extruded out onto the surface in a manner similar to Earth's rhyolite and dacite domes. The features we have described provide preliminary evidence for the presence of intermediate-to-silicic magma on Venus. A similar dome is located near the Venera 8 landing site[14]. We are presently documenting several other examples of such domes and are examining their geologic settings and relationships in order to further assess petrologic diversity and crustal evolution on Venus.

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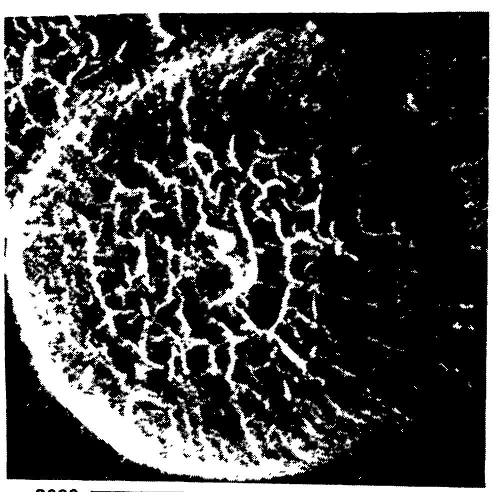

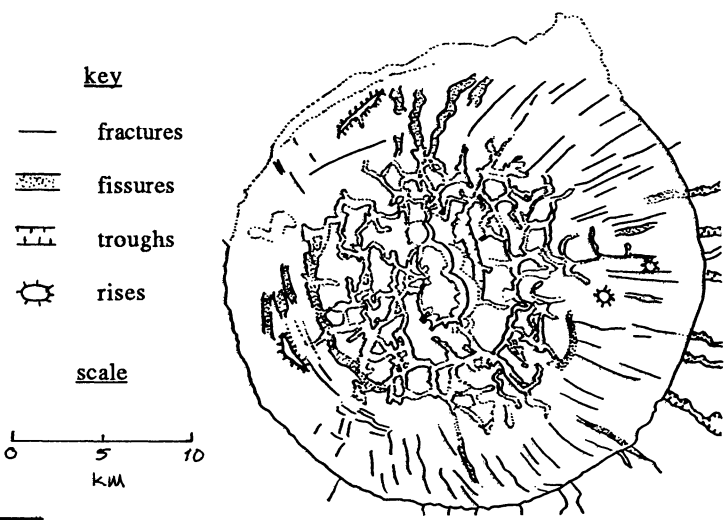

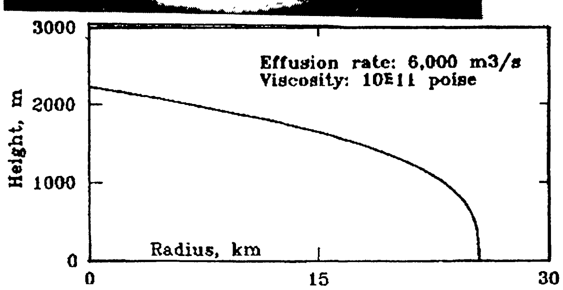

figure 1a: dome image (above left)

figure 1b: lineament map (above right)

figure 2: modeling example (left)