DETERMINING THE ALTITUDE OF RESERVOIR-DERIVED VOLCANIC FEATURES ON VENUS.

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Introduction: Mathematical models used to explore the conditions under which neutral buoyancy zones and magma reservoirs can form on Venus suggest there should be an altitude-dependent distribution of reservoir-derived volcanic features [1]. Specifically, for basaltic magma with typical (0.2-0.4 wt%) volatile contents, the models predict a paucity of edifices below 6051 km, and a gradual increase in edifice size as well as a gradational change from extrusive to intrusive features with increasing altitude and hence increasing reservoir depth [1]. These predictions are generally consistent with studies of the altitude dependent distribution of intermediate and large volcanoes as well as giant radiating dike swarms [2-5]. However, although these global scale studies provide valuable insight into the formation of reservoir-derived volcanic features on Venus, in general they do not carefully evaluate whether or not stratigraphic or topographic changes have altered the elevation and/or morphometry of individual features subsequent to their formation. To resolve this, the specific geologic setting for each reservoir-derived volcanic feature may need to be examined. Here, using a suite of different volcanic features from the Nemesis Tessera quadrangle (V14), we explore whether elevation measurements which factor in careful consideration of geological history differ from the elevations obtained using methodologies employed in previous, global scale studies.

Methods: Due to the different characteristics of each type of volcanic feature, guidelines specific to each feature were used to determine their altitude. The objective was to determine the surface elevation present when each reservoir-derived feature formed, drawing upon methods used in prior studies to facilitate comparison.

In the case of both large and intermediate volcanoes, the basal elevation was defined as the average plains elevation around the extent of the most distal flows, consistent with previous studies [2,3]. More specifically, for large volcanoes an average of several points at unspecified locations was used [3] while for intermediate volcanoes the average of four points defined by the intersection between N-S and E-W lines and the edges of the volcano was used [2]. Both of these methodologies assume distal flows were emplaced at what used to be the basal elevation of the edifice. Thus, they ensure that edifice topography wasn't included in elevation calculation. We chose to use eight points on the perimeter to determine our initial elevation, but even this methodology doesn't inherently account for the local geography (i.e., rifting, other volcanic features) that may have modified the local topography subsequent to when a given volcano formed. To explore one remedy for this, we used synthetic stereo data and stratigraphic interpretations to eliminate points that occurred in areas deformed significantly after the volcano was emplaced, then recalculated our average altitude to correct for these topographic changes. By definition this is a subjective process requiring thorough stratigraphic interpretation, but it permits more careful consideration of the post-emplacement geological history when attempting to evaluate the conditions under which emplacement occurred.

For giant radiating dike swarms, previous studies calculated the mean elevation over a circular area the radius of which is the size of the longest dikes observed [4], a conservative approach. This method follows the logic that dikes are emplaced laterally from a magma reservoir along a level of neutral buoyancy, and consequently the presence of dike-induced lineaments implies the existence of a level of neutral buoyancy across the intruded area. We refined this by using the mean altitude over a circle extending out to the most common dike radius. Excluding the longest dikes gives us the altitude at which most dikes form, allowing both ease and reproducibility for the calculation. A potential problem with this method is that not all dike swarms are circular; a better approach would be to examine topography only where dike-induced lineaments exist. In addition, the area intruded by the swarms is usually quite large, suggesting that this form of elevation measurement is quite susceptible to post-emplacement deformation.

Discussion: Analysis of reservoir-derived volcanic features reveals several different problems which may affect the applicability of previous studies. Figure 1 shows the effect of post-emplacement tectonic deformation on the elevation calculation for a large volcano, whereas Figure 2 illustrates another potential problem, the misinterpretation of reservoir-derived volcanic features in radar imagery. This volcano has essentially no topography, and the center of the small caldera at the summit is in fact 200 m lower than the surrounding plains. Figure 3 illustrates the potential problems with a recently identified fanning dike swarm [6]; this feature is not part of the existing volcanic catalog [7]. Furthermore, it does not fan through 360 degrees of arc and the topography is highly variable within the small area the dikes have intruded.

As a case study, we consider Nijole Mons (Figure 1). If an average of only four cardinal points is used, the basal elevation for this large volcano would be 6051.24 km. If we use eight measured points instead, the basal elevation is 6051.35 km, a difference which is a substantial portion of the volcano's relief. If, however, we eliminate points affected by post-emplacement deformation from consideration, the basal elevation drops to 6051.10 km. This difference occurs because the elevation of the flows which define the perimeter of the volcano are affected in some places where Akewa Dorsa, an E-W deformation belt, has altered the topography of the volcano: there is over a kilometer difference between the high and low values for the individual data points collected on the perimeter. Since the heights of volcanoes on Venus are generally less than 2 km [3], even small variations in height are significant. Careful consideration of the post-emplacement history would seem to be necessary to evaluate the altitude at which this volcanic feature was emplaced, and hence previous studies may need to be refined to improve our understanding of whether neutral buoyancy has played a major role in the formation of reservoir-derived volcanic features on Venus as predicted.

References: [1] Head, J.W. and L. Wilson (1992). *JGR*, *97*, 3877-2903. [2] Ristau, S., *et al*. (1998). *LPS XXIX* Abst. #1100. [3] Keddie, S.T and J.W. Head (1994). *Planet. Space Sci.*, *42*, 455-462. [4] Grosfils, E.B. and J.W. Head (1995). *Planet. Space Sci.*, *43*, 1555-1560. [5] Grosfils, E.B. *et al*. (2000). Environmental Effects on Volcanic Eruptions: From Deep Oceans to Deep Space, 113-142. [6] Doggett, T. and E.B. Grosfils (2002) *LPS XXXIII* (this volume). [7] Crumpler, L.S. *et al*. (1997). Venus II, 697-756.

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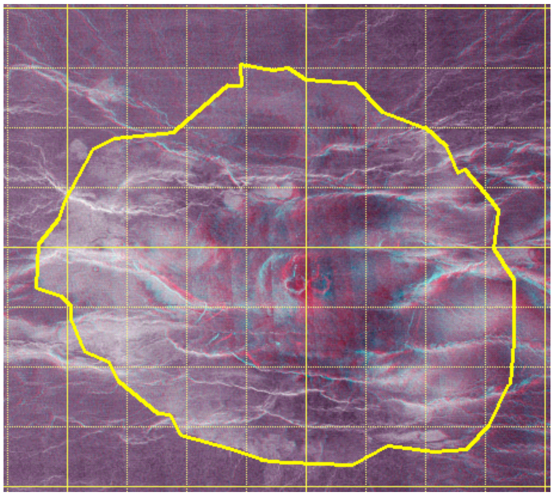

Figure 1: Stereo image of Nijole Mons, a large volcano centered at 44.73°N, 184.73°E. Line marks edge of distal flows. Squares of light grid are 25 km on a side, and north is at the top of the image.

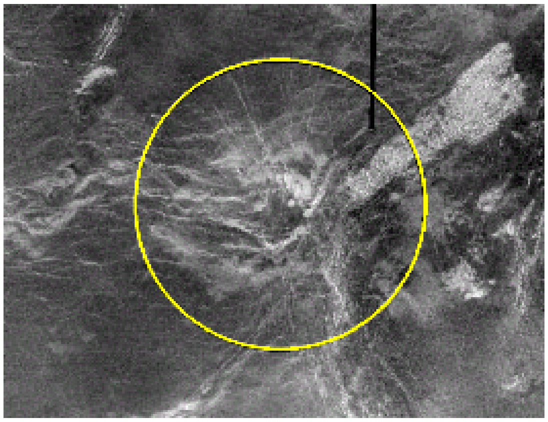

Figure 2: Previously unidentified radiating dike swarm centered at 44.96°N, 190.88°E; see [6] for details. Circle is the area over which the altitude was calculated, and is 205 km in radius. North is at the top of the image.

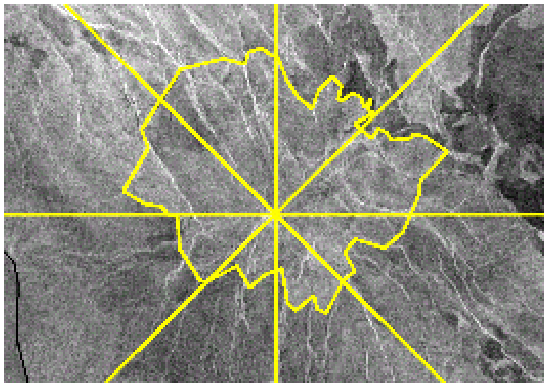

Figure 3: Image of large volcano centered at 40.29°N, 205.83°E. Radial spokes shown were used in altitude calculations. Summit caldera (beneath focus of spokes) is lower than surrounding plains. Line marks edge of distal flows, and the volcano is approximately 125 km in diameter. North is at the top of the image.