Uplift of Venus Geoid Highs: Timing from Coronae and Craters Paul R. Stoddard, Department of Geology and Environmental Geosciences, Northern Illinois University, DeKalb IL 60115-2854, USA, prs@geol.niu.edu
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Introduction: Crater distribution on Venus indicates that the surface has undergone global-scale resurfacing in a short period of time [1]. Determining the timing of events has been difficult due to the near-random crater pattern. Some progress has been made in the relative dating of various types of features [2,3,4]. In addition, current deformation of Venus' surface has been described as a swell-push force, defined as the gradient of the geoid height [5]. Two likely areas of current geologic activity, Atla Regio and Beta Regio are marked by most prominent geoid highs. We compare these two features in terms of coronae and craters to establish the relative timing of the their formation.

Corona and Chasm Classification: DeLaughter and Jurdy [4] have classified 394 coronae based on the morphology of the interior - domal, circular, and calderic. They proposed that these differing styles reflect different stages in the evolution of a corona, with the domal representing the youngest, possibly active features, then progressing through increasing degrees of collapse to the calderic coronae. Comparison of elevations of these features shows the domal coronae, on average, to occur at higher elevations and calderic at lower elevations, with circular in between (Figure 1). If elevation can be

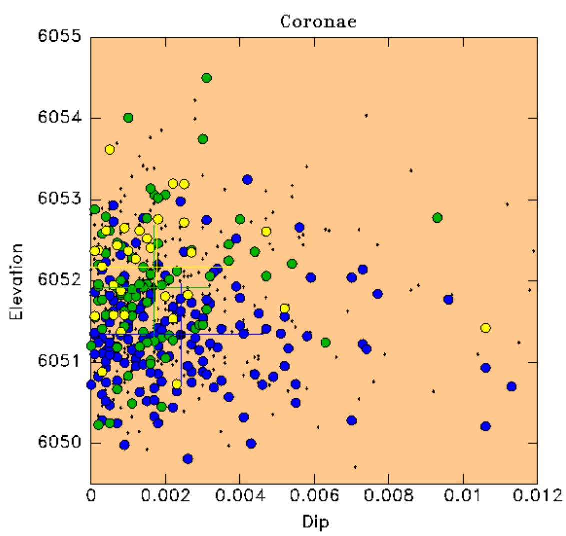

Figure 1: Comparison of dip (degrees) vs. elevation (km) for domal (yellow), circular (green) and calderic (blue) coronae. Diamonds with cross hairs indicate averages and standard deviations.

associated with dynamic activity, then those areas that are highest should also be youngest, and consequently the higher elevation coronae (domal) should be younger than those (calderic) at lower elevations. Jurdy and Stoddard [6] attempted to relate types of coronae to different chasmata in the Beta-Atla-Themis (BAT) region, and suggested that the chasmata may also be of different ages and states of activity. We now consider the timing of uplift of Beta and Atla Regios.

The Regios: Beta and Atla are both marked by pronounced topographic and geoid highs. Each lies at the intersection of multiple rift systems, and thus represent two of the best candidates for active processes. We look at distribution, style, and attitude of coronae, and location, tectonization, and embayment of craters with respect to these two highs.

Venus hosts approximately 940 craters, of which about 158 are tectonized, and 55 embayed, but only 19 worldwide are both tectonized and embayed [1]. Of these, four are near the crest of Atla, and one on its flanks, while Beta is home to three on its flanks and one on its crest. In addition, Beta and Atla have high relative percentages of craters that have been tectonized or embayed (Figure 2). As the distribution of craters approximates random, one can not infer

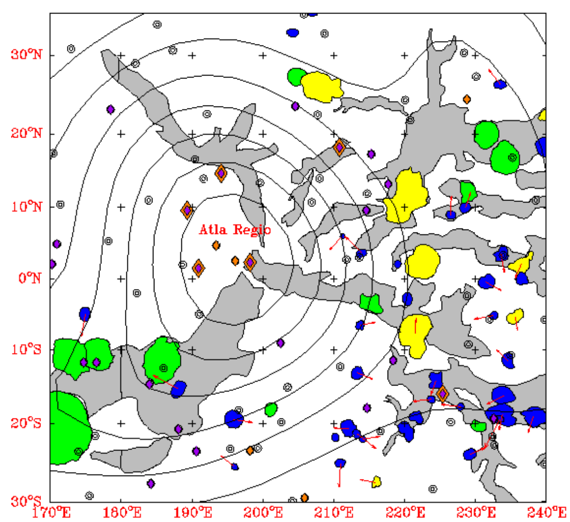

Figure 2a: The Atla Regio region. Geoid is indicated by 10-meter contours. Craters: small circles unmodified; orange diamonds embayed; purple diamonds tectonized; purple within orange tectonized and embayed. Grey regions indicate rifts. Corona color scheme same as in Figure 1. Red arrows indicate dip directions, where attainable.

much about relative ages of features; however, areas of high concentration of altered craters can safely be inferred to have been more active. An area with most or all of its craters altered, such as the crest of Atla, must have only recently ceased activity or still be active, otherwise one would expect some recent craters to be pristine. We may therefore infer that Atla, with a higher percentage of altered craters, (8/17 or 47%, within three contours of the summit) than Beta (4/14 or 29%, in the same range) is a younger feature than Beta. Both are younger than "average" terrain ((158 T + 55 E)/940 = 23%). Besides the evidence of tectonic/volcanic forces modifying craters, there's a slight but systematic deficit of about 20-30 craters close to the chasmata [7].

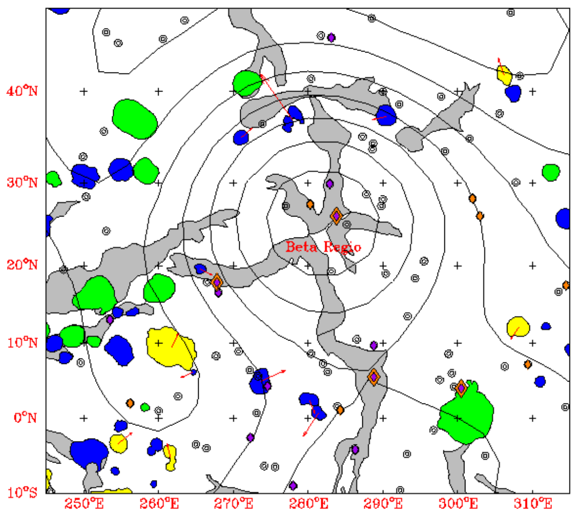

Figure 2b: The Beta Regio region. Symbols are the same as in Figure 2a.

We next consider coronae. Both Atla and Beta are ringed by many coronae, but neither has coronae at or near their crests, i.e. within 2 contours (20 meters) of the geoid high (Figure 2a, 2b). Coronae do occur in many rift segments, yet none occurs at these intersection points. Perhaps just as remarkable, Atla has a partial ring of four domal coronae, all between 4 and 5 geoid contours from the crest, while Beta has a partial ring of 6 or so calderic coronae between three and four contours from its crest. In both instances, the rings parallel geoid contour lines, and are the nearest coronae of their type to the crests. If corona formation at some critical distance is in fact contemporaneous the uplift process at Atla and Beta, and if the domal are younger than the calderic, then Atla should be younger than Beta, in agreement with the modified-crater analysis.

If this dating scheme is accurate, and uplift of Atla postdates formation of calderic coronae, then we would expect the latter to be tilted away from the center of uplift at Atla. Conversely, if calderic coronae formed concurrently with the uplift of Beta, (or domal formed concurrently with Atla uplift) then we would not expect to see such a pattern of dips. To test this, we determined the average dip of each corona (red arrows in Figure 3a, 3b). These determinations are at best very rough, but there is a suggestion that the calderic coronae dip away from Atla's crest, especially for those immediately west of the uplift. Neither the domal features at Atla nor the calderic features at Beta show such a pattern.

Conclusions: We utilize two independent schemes for assessing the relative timing of the uplift of Atla and Beta Regios. Both schemes, percentage of craters altered, and style of corona, suggest a younger age for the uplift of Atla. Another test of this result, examining the dip directions of coronae near each uplift, is consistent with the younger age for Atla. On the basis of dark halos Basilevsky and Head [8] have also come to the conclusion that Atla younger than Beta.

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