A NEW LOOK AT THE RELATIONSHIP BETWEEN FRACTURE ANNULI AND TOPOGRAPHIC RIMS AND TRENCHES AT VENUSIAN CORONAE.

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Introduction: Coronae are intriguing circular to oblong features on the surface of Venus, and range in diameter from 75 km to >1000 km. A corona is defined by its circumferential ring of fractures, or fracture annulus, and often has a circumferential topographic rim and/or trench. Two types of coronae exist: Type 1 coronae have > 180° of a fracture annulus, and Type 2 coronae have < 180°, but possibly a complete topographic rim [1]. Classification systems exist for both types: there are 5 classes of fracture annulus morphologies (concentric, concentric-double ring, radial/concentric, asymmetric, and multiple) [2] and 9 groups of topographic profile patterns, based on interior lows or highs and exterior troughs and/or rims [3].

We systematically examine relationships between morphologic and topographic signatures using radial profiles of coronae for a broad range of coronae in order to compare the location of fracture annuli, which should represent the location of maximum bending, to models predicting topographic rim evolution. Further, these parameters have not been thoroughly compared between types 1 and 2 coronae [1], [2].

Various formation mechanisms have been proposed for coronae, including lithospheric subduction [4], mantle upwelling [5], upwelling and coupled lithospheric dripping [3], and lithospheric instabilities [6], [7]. Each of these models has specific resulting

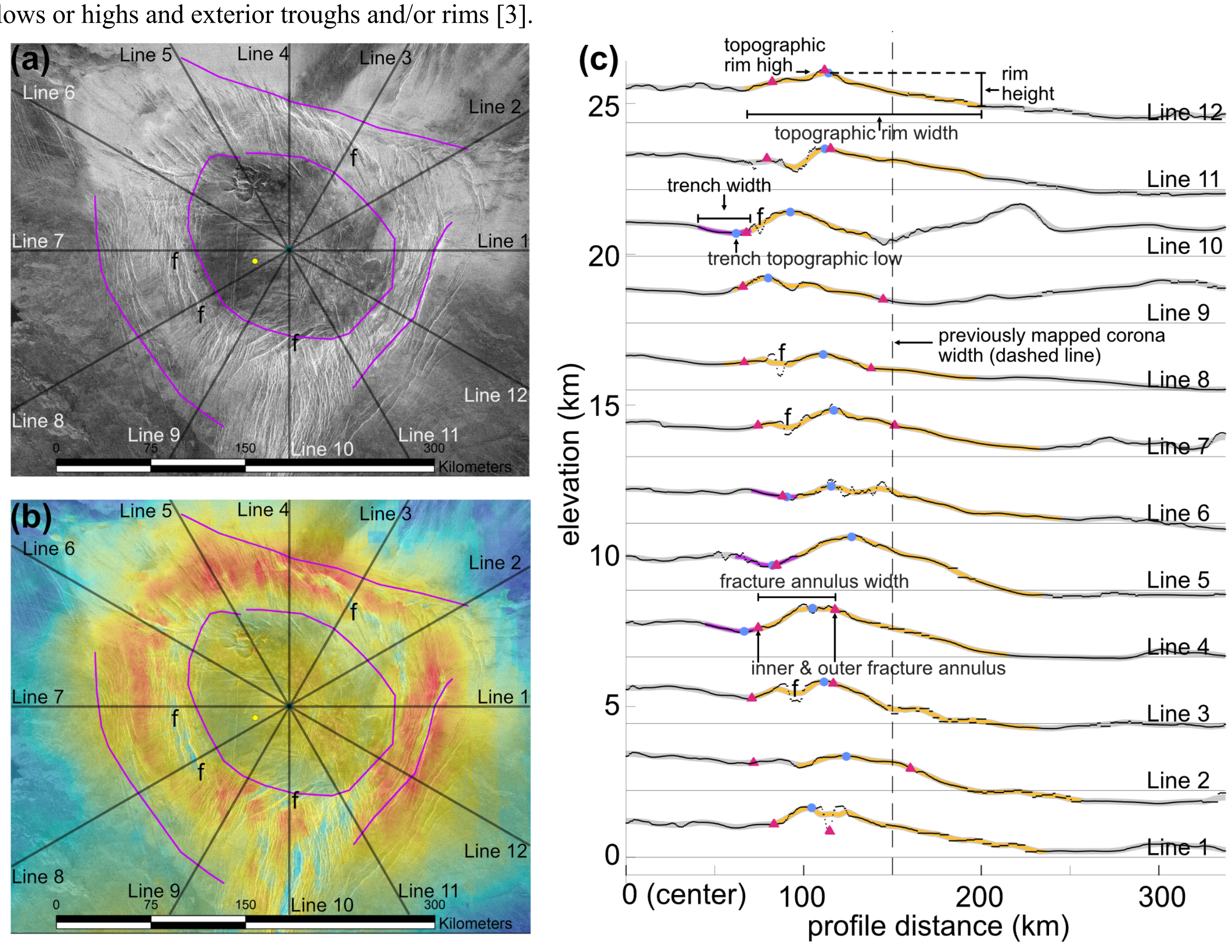

Figure 1: Example of radial profiles of Sappho corona; fractures labeled as f. (a) left-look SAR map with purple lines indicating inner and outer extent of fracture annulus, black lines indicating profile line number shown in (c); (b) stereo-derived topography [10] of same map extent and features in (a); (c) radial profiles of lines 1-12 shown in (a) and (b) with previously mapped corona width (dashed line, i.e., [2]), each profile with mean planetary radius (thin black line), stereo topography (black datapoints), smoothed topography (grey line), topographic rim (yellow highlight), trench (purple highlight), topographic rim high and/or trench low (blue dots), and inner and outer fracture annulus (pink triangles). Also shown is the topographic rim width/height, trench width, and fracture annulus width.

topographic and/or morphologic signatures, such as patterns of rims, troughs, domes, and depressions.

A few models are summarized here. For example, during central downwelling of the lithosphere-asthenosphere boundary, the Rayleigh-Taylor instability can produce small depressions which evolve into domes or depressions over time as a mechanism for coronae formation [8]. The same Rayleigh-Taylor instability can also produce plateaus evolving into rims surrounding depressions, rims only, or rims surrounding interior highs from central upwelling [8]. As the topographic rim location and width evolves over time, the maximum curvature also changes. Extensional fractures should form when there is sufficient curvature, and may be most pronounced when there is maximum curvature, such as outside a depression in cases of downwelling, or between plateaus and trenches in cases of upwelling. We will investigate if indeed extensional fracture locations match the location of maximum curvature, and if the fractures occur in particular areas relative to the topographic rim.

In another example focused on extension and the Rayleigh-Taylor instability as mechanisms for coronae formation, topographic rim heights vary from 100 m to ~700 m, depending on properties including rift width and the location off-center of lithospheric drip [7]. In these models, the maximum curvature of the rim often migrates outward. We expect that fracture annuli will only form when there is sufficient curvature (i.e. [9]), such that they will form in areas of maximum curvature, but be left behind as the curvature changes. We measure rim heights from topographic profiles and investigate whether fracture locations align with maximum curvature, or if they are in any particular location relative to current rim position.

Last, we investigate differences between types 1 and 2 coronae. Type 2 coronae tend to be smaller, more commonly isolated and found in plains than Type 1 [1]. Three hypotheses for the formation of these two types include (1) a strong lithosphere, in which rims without fractures have less curvature, (2) slow viscous bending, which could allow rims for form without forming fractures [1], and (3) regional stress fields may suppress particular orientations of fractures. We compare the presence and dimensions fracture annuli and topographic rims of types 1 and 2 coronae.

Coronae are interesting as an insight to interior dynamics of Venus, and our study comparing morphologies of coronae to models of their evolution allows us to assess the stage of evolution of a given corona, thus giving an approximate minimum age for a particular corona's formation. We aim to systematically assess the validity of these models compared with topography and fracture annulus morphologies of Venusian coronae.

Methods: We analyze coronae covered by topography derived from stereographic radar imagery [10], with a resolution of ~1 km, covering ~17% of the surface [11]. For each corona, we map fracture annuli and produce 12 radial topographic profiles, marking the intersected fracture annuli. From the profiles, we measure widths and heights of topographic rims and trenches and fracture annulus widths (Figure 1).

Preliminary results: Early analysis of 14 Type 1 coronae shows that fracture annulus widths range from 20 to 90 km, which is comparable to prior mapping results of 10-150 km [2], and narrower than the topographic rims, which range in width from 70 to 190 km. Rim heights range from 350 to 1200 m.

Analysis of 11 Type 2 coronae [12] reveal fracture annulus widths ranging from 30 to 180 km, topographic rim widths ranging from 70 to 150 km, and topographic rim heights ranging from 390 to 1200 km.

Implications: A better understanding of the relationship between topographic rims and fracture annuli allows us to assess the validity of different deformation models for coronae, as mentioned above. Our preliminary results show much wider topographic rims than fracture annulus widths, indicating that the current topography is a result of relaxation, and that prior topography produced the fractures.

So far, Type 2 coronae have remarkably similar topographic rim heights and widths to Type 1, although their fracture annuli appear far murkier in imagery. As we add data and compare to Type 2 coronae [12], we will better understand the different formation mechanisms of coronae, and what distinguishes Type 1 from Type 2.

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References:

[1] E.R. Stofan and S. E. Smrekar (2001) *GRL, 20,* 4267-4270. [2] E. R. Stofan *et al.* (1992) *JGR, 97* 13347-13378. [3] S. E. Smrekar and E. R. Stofan (1997) *Science, 277,* 1289-1294. [4] D. T. Sandwell and G. Schubert (1992) *Science, 257,* 766-770. [5] M. Janes *et al.* (1992) *JGR, 97,* 16055-16067. [6] P. M. Grindrod and T. Hoogengoom (2006) *Astronomy & Geophysics), 47,* 3-16. [7] D. Piskorz *et al.* (2014) *JGRP, 119,* 2568-2582. [8] T. Hoogenboom and G. A. Houseman, (2006), *Icarus, 180,* 292-307. [9] J. G. O'Rourke and S. E. Smrekar (2018) *JGR 123*, 369-389. [10] R. R. Herrick *et al.* (2012) *Eos, 93,* 125-126. [11] S. Hensley *et al.* (2019) *IEEE* 6023-6026. [12] M. Carrington et al. (2021) *AGU 2021,* Abstract #P35H-2220.