CORONA FORMATION ON VENUS VIA EXTENSION AND LITHOSPHERIC INSTABILITY.

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Introduction: The thermal history of Venus remains an enigma. As Venus and Earth have similar radii and radiogenic abundances, we assume they have similar internal structures and internal compositions [1]. It does not appear to have plate tectonics, and its surface displays a range of volcanic and tectonic features, including those that are both similar and dissimilar to those on Earth [2,3]. Here, we study coronae in rift environments with the goal of understanding Venus's unique evolutionary path.

Background: The Magellan mission observed semi-annular volcano-tectonic features called coronae dotting the surface of Venus (see Figure 1) [4]. There are over 500 observed coronae on Venus [5].

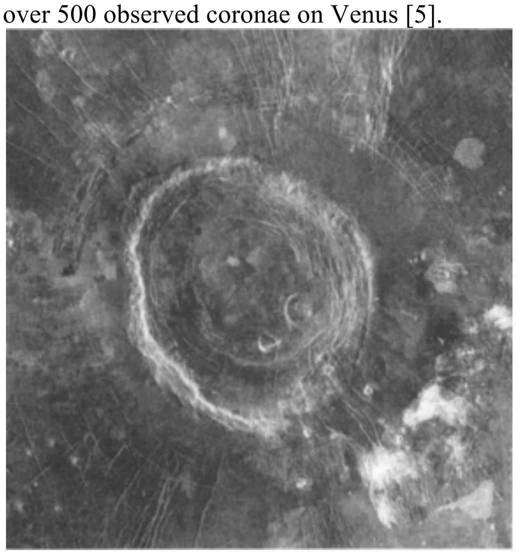

Figure 1. *Magellan SAR image of a corona. Image is 375 km across. Taken from Figure 2a in [4].*

Characteristics of coronae. Coronae diameters range from 60 to 1060 km with a mean diameter of 250 km. There are nine topographic groups of coronae, ranging from domes to depressions, and from rims surrounding interior highs to rims surrounding depressions [6]. Dome and plateaus tend to show high volcanism, while depressions show low volcanism. Coronae with radial fracturing show high volcanism, while coronae with more concentric fracturing show low volcanism [7].

Association of coronae with rifts. There are 50 coronae associated with Hecate Chasma and 131 with Parga, the two largest rift systems on Venus. The coronae form at different times relative to the rifts making it difficult to determine a genetic relationship. At Parga Chasma, there are 55 off-rift coronae located 150 to 1500 km from the rift, meaning that their formation times relative to the rift cannot be determined. These off-rift coronae are generally smaller and less volcanic than the average corona and tend to have negative topographies [7].

In the absence of plate tectonics, the origin of major rift systems like Parga is unclear. Are coronae important in the formation of rifts, or vice versa? How do they contribute to planetary heat loss?

Proposed methods of coronae formation. There are many proposed coronae formation mechanisms, including mantle upwelling or downwelling with associated lithospheric drips [4] and Rayleigh-Taylor instabilities at the lithosphere-mantle boundary [8]. Another theory suggests that the interaction between the edge of a plume head and a depleted mantle layer can produce the full range of coronae topographies [9].

This project proposes that a mantle plume or upwelling associated with a rift mobilizes eclogite in the lower lithosphere off-axis of the rift, causing lithospheric dripping into the upper mantle, leading to extension, surface stresses, melting, and the creation of off-rift coronae. By further characterizing the connection between rifts and coronae, we may be able to further understand the subsurface dynamics of a single-plate planet.

Experiments: Numerical models are run in Cartesian coordinates with Conman [10] to simulate the rift geometry and in spherical, axisymmetric coordinates with SSAXC [11] to simulate coronae formation. These are finite-element codes that solve equations for the conservation of heat, momentum, and mass given initial temperature and compositional profiles. Our models consist of a conductive lithosphere and a convective mantle with a rift, plume, and density contrast representing eclogite at the lithosphere-mantle boundary. We perform resolution tests and account for edge effects.

As shown in Figure 2, the specific procedure involves first running the model in Cartesian coordinates until the interaction of the rising plume and the dense material at the lithosphere-mantle boundary creates instabilities far from the rift (A & B). Next, we extract a successful drip and run that portion in spherical axisymmetric coordinates to focus on the topography of the fundamentally axisymmetric process (C & D).

We vary lithospheric thickness, or the non-rifted region with a conductive temperature profile, (75, 88, and 100 km), as well as rift half-width (50 and 100 km), and plume temperature (1400 and 1500°C). We use a mantle temperature of 1300°C, mantle density of 3300kg/m^3 and reference viscosity of 10^{20}Pa·s. The composition varies from 120% to 100% of the mantle density.

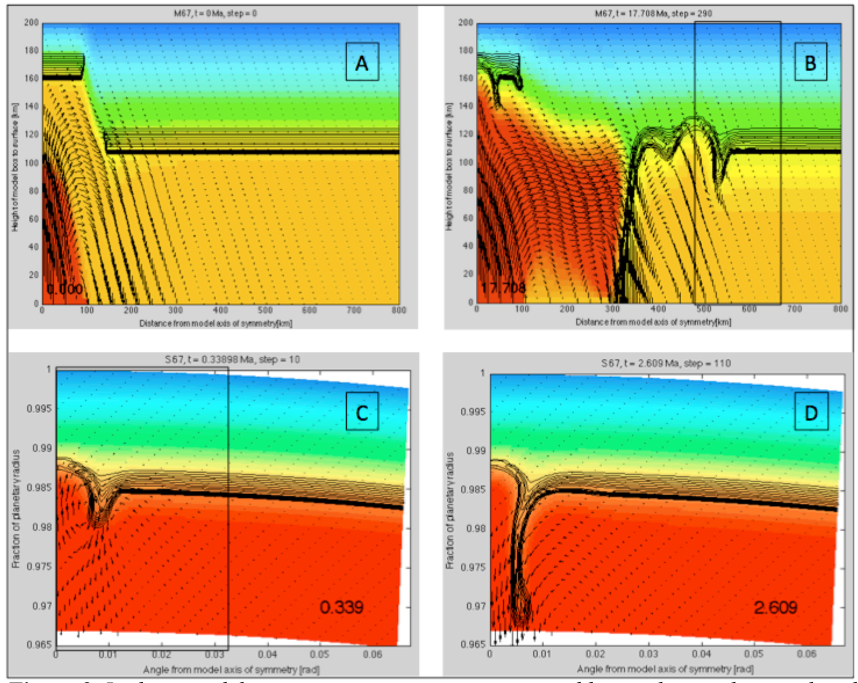

Figure 2*. In these model setups, temperature is represented by a color gradient with red being the hottest; compositional changes are represented by the black contours. Note the temperature gradients are different for A & B (1500 to 480°C) compared to C & D (1300 to 480°C). Model Box A represents a 1500°C rising plume underneath a rift with a 50-km half-width and an 88-km thick lithosphere in Cartesian coordinates. Model Box B shows the evolution of the drips from Model Box A. The box drawn within Model Box B matches the box drawn in Model Box C. Model Box C is in spherical coordinates with the left-hand side acting as the axis of symmetry. Model Box D shows the evolution of the drip.*

Results and Discussion: For the models that produce substantial lithospheric dripping, we calculate topographies, melt volumes, and gravity anomalies.

The drips produced in our models produce eight of the nine coronae topographies, the ninth being "no discernable signature," as described by Stofan et al. in their paper "Coronae on Venus: Morphology and Origin" [7]. Our coronae tend to have centers between 240 and 680 km from the rift center, similar to observed off-rift coronae.

Conclusions and Further Work: Thus far, our topography calculations match observations; we intend to carry out gravity anomaly and melt calculations as well.

We have shown that it is possible to produce reasonable off-rift coronae resulting from the interaction between a rising plume associated with a rift and a pre-existing layer of dense material at the lithosphere-mantle boundary.

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