CORONA STRUCTURES AT TOPOGRAPHIC MARGINS ON VENUS REVEAL INTERIOR DYNAMIC PROCESSES. A. J. P. Gülcher[123], T. Yu[4], D. Stadler[1], and T.V. Gerya[1]. [1]Institute of Geophysics, ETH Zürich, Switzerland [2]California Institute of Technology, Pasadena, CA [3]NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA [4]Georgia Institute of Technology, GA (anna.guelcher@erdw.ethz.ch).

Summary: We present a joint study of mission data analysis and 3D modelling of coronae structures on Venus. Our analysis reveals that the majority of coronae on Venus show asymmetrical features and are positioned on a topographic margin. With state-of-the-art 3D numerical models, we investigate the physical processes behind plume-margin interactions on Venus, and make important conclusions on the physical processes responsible for Venus' geology.

Introduction: Venus is the only other Earth-sized planet in the Solar System and is often called our planet's 'twin sister'. Venus does not exhibit evidence of plate tectonics, yet the planet's surface is littered with tectonic and/or volcanic structures. Such surface deformation is mainly driven by mantle convection and plume-lithosphere interactions, of which perhaps the most enigmatic surface manifestations are the circular volcano-tectonic features called "coronae". Coronae are ~circular crown-like structures often linked to mantle plume upwellings and/or magmatism. Unravelling their origin may hold clues for Venus' resurfacing history as well as lithospheric structure.

Prior numerical studies of plume-lithosphere interactions on Venus reproduced several key features of radially-symmetrical coronae and gave important insights into the planet's present-day tectonic activity [1,2]. Yet, in nature, many Venusian coronae show asymmetric features and some are inferred to host focused subduction at a single side. It remains unknown exactly how such asymmetric coronae develop and what they can reveal about the planet's interior.

Coronae morphology classification: Here, we present new results from our systematic analysis of the 133 largest coronae on Venus (database from [1]) in terms of surface morphology. We establish that 70% of these coronae are radially-asymmetrical, and we further sub-categorize them based on their relation to their surrounding topography. 'Intrinsically asymmetrical' coronae (*I*) are situated in a region of otherwise ~homogeneous topography with little variations in topography. 'Topographic margin' coronae (*II)* are (partially) situated on a topographic margin. Finally, 'irregular topography' coronae (*III*) are bounded by complex terrain (such as chasmata rifts and/or corona clusters).

The outcomes that most coronae have asymmetrical topographic features and that a substantial part are positioned on a topographic margin (see Fig. 1) drive our subsequent numerical study on the dynamics of plume-margin interactions and related coronae formation on Venus.

3D numerical modelling: We present prompting-new 3D numerical models of the interaction of a thermal mantle plume with a laterally-heterogeneous Venusian lithosphere (i.e., a linear topographic margin bounding a lowland and a crustal plateau on each side). These high-resolution magmatic-thermomechanical models were run with the code I3ELVIS [3]. We systematically

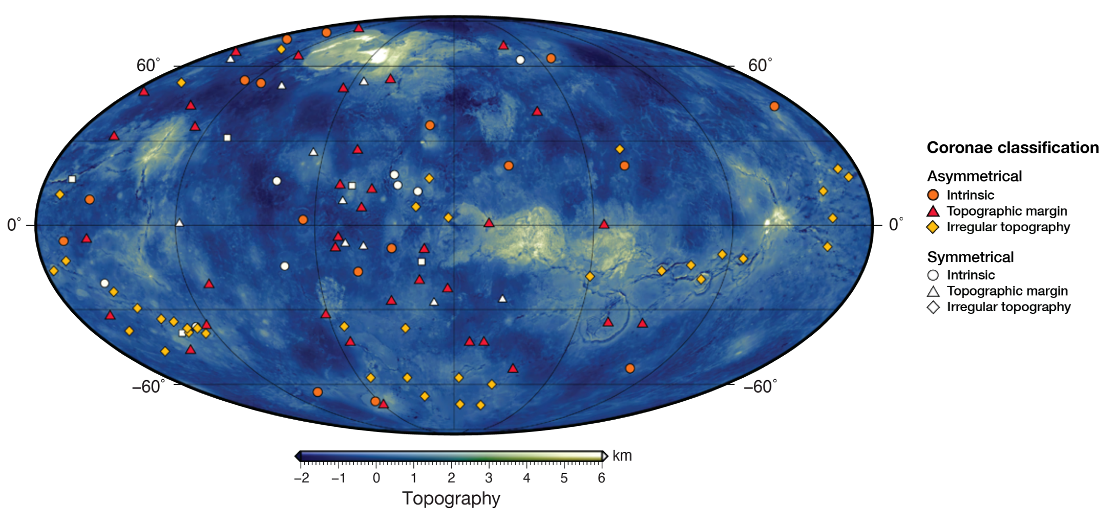

Figure 1. Global distribution of (a)symmetrical coronae on Venus, subcategories based on the relationship with their surrounding topography. A Mollweide projection centered at 60°E is used and the global topography is relative to 6051.877 km.

varied parameters related to the crustal and lithospheric configuration, such as the crustal plateau thickness, lithospheric age (coldness) of the plateau, and the transition width of the topographic margin (see Fig. 2).

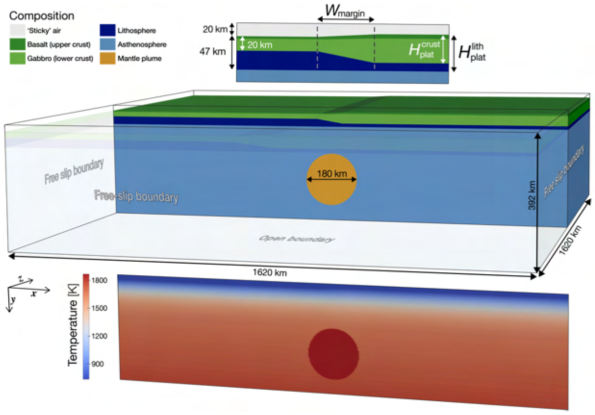

Figure 2. Numerical model design and boundary conditions. 2D cross sections through the center of the model show the initial composition (top) and temperature profile (bottom).

The results reveal several distinct tectonic regimes responsible for asymmetric corona formation on Venus, and that the coronae morphology is directly related to the crustal and lithospheric structure the mantle plume impinges. The following tectonic regimes are identified:

Lowland-sided subduction: In our models, asymmetrical coronae development often features a short-lived subduction zone episode in which the subducted slab retreats into the lowland side. In this scenario, a deep trench forms in the lowland throughout most of the coronae evolution (Fig. 3).

Plateau-sided lithospheric dripping: When the rising mantle plume encounters a topographic margin with a thick- or cold-enough crustal plateau, one or multiple plateau-sided lithospheric dripping episodes develop. The corona topography features a deep trench in the plateau for most of its evolution (Fig. 3).

Trench-polarity reversal: Several models reveal polarity reversal of the topographic trench due to a shift in the geodynamics from plateau-sided lithospheric dripping to lowland-sided subduction.

Discussion: The tectonic regimes described above depend strongly on the lithospheric and crustal structure, and we establish links between coronae morphology with one-sided subduction and subduction polarity reversal. Via integration of the 3D modelling results with the new coronae analysis, we present our predictions of the processes that shape(d) Venus' surface. Finally, we shed light on what future data is needed to better constrain the Venusian lithospheric structure and the dynamic processes underneath.

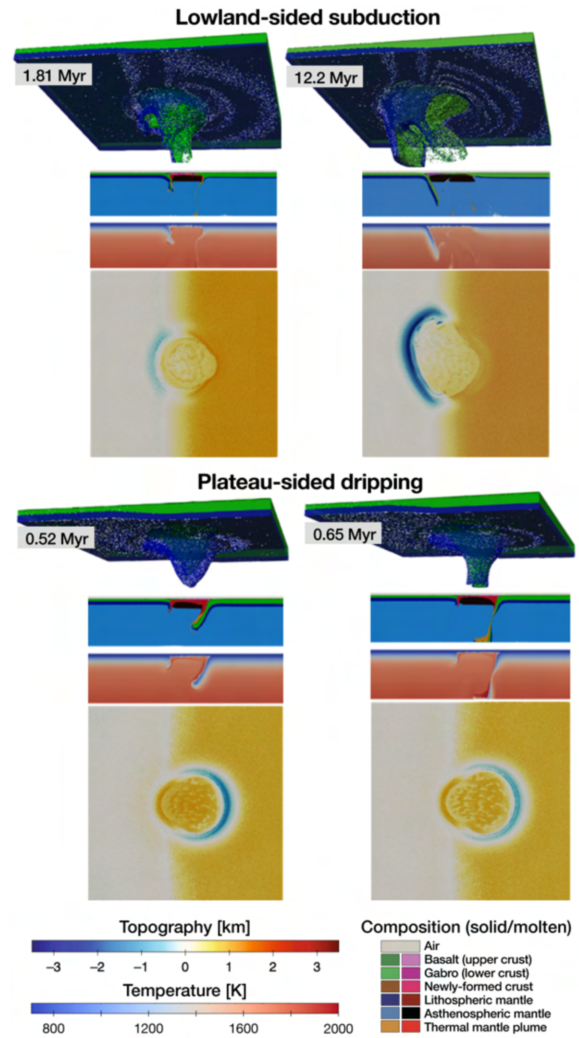

Figure 3. Model results of the plateau-sided dripping (top) and lowland-sided subduction (bottom) regimes, including views of composition, temperature, and surface topography.

Acknowledgments: For our coronae morphology classification, Magellan topography data from [4] was analyzed with the Generic Mapping Tools software [5]. Google Venus [6] including the IAU/USGS Venus Nomenclature [7] was used to identify spatial relationships and other surface features.

References: [1] Gülcher et al., (2020), *Nat. Geosci.,* 13, 547-554. [2] Piskorz et al., (2015), *J. Geophys. Res.* **119**, 2568–2582. [3] Gerya, T. V. and Yuen, D. A., (2007), *Phys. Earth Planet. Inter.* 163, 83–105. [4] Sandwell, D., (2014), ftp://topex.ucsd.edu/pub/sandwell/google/venus. [5] Wessel, P. and Smith, W., (2013), Generic Mapping Tools. *EOS Trans. AGU* 94, 409–410. [6] Sandwell et al., (2018), Google Venus. https:/topex.ucsd.edu/venus/index.html. [8] Gazeteer for Planetary Nomenclature*, USGS Astrogeology Science Centre*, https://planetarynames.wr.usgs.gov