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# Constraining the evolution of Venusian rifts: an integrated observation and modelling approach

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Increasing observational evidence and recent geodynamical modelling indicate that Venus may have experienced or may still experience tectonic-like processes (Sulcanese et al., 2024; Gülcher et al., 2025). In fact, surface deformation is believed to be driven primarily by mantle convection and plume-lithosphere interactions, producing a wide range of tectono-volcanic features (Smrekar et al., 2023). A key expression of this deep dynamics is the global network of rifts (chasmata), which extends for thousands of kilometres (Graff et al., 2018; Brossier et al., 2022). However, their driving mechanisms, temporal evolution, and lithospheric structure remain poorly constrained as a result of limited observational data. Therefore, constraining the evolution of Venusian chasmata is essential to understanding the interior dynamics of the planet and its evolution.

In this study, we used forward 2D numerical models to constrain the rates, durations, and lithospheric structures of extensional processes, integrating observational evidence from topography and gravity anomalies to improve our understanding of Venusian rifting. In particular, we tested different extensional velocities and lithospheric and crustal thicknesses.

For comparison with topographic and gravity observation, we extracted 12 topographic cross-sections along 28 Venusian rift axis. To minimize 3D effects when compared with our 2D numerical models, we evaluated the longitudinal variability of topography by grouping three or more adjacent cross-sections and computing their mean profiles. Only portions of the rifts that did not show statistically significant variations in topography were considered for our comparison. We then compared the mean topography of these rift portions with the topography predicted by the models. Finally, we compared the gravity anomalies derived from the selected rift portions with the gravity anomalies extracted by the models.

We observed that extensional velocities between 0.5 and 2 cm/yr reproduce the observed topography well, while lower velocities often do not allow for the development of rifting structures. In addition, models with a lithospheric thickness of 100 km and a crustal thickness of 15 km show the best topographic fit with observations. Finally, comparing the observations with the evolution of the models at different times allows us to recognize an asynchronous evolution in

the Diana chasma, with differences of approximately 1 Myr along its axis.

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