Evolution of Venusian rifts: Insights from Numerical Modeling

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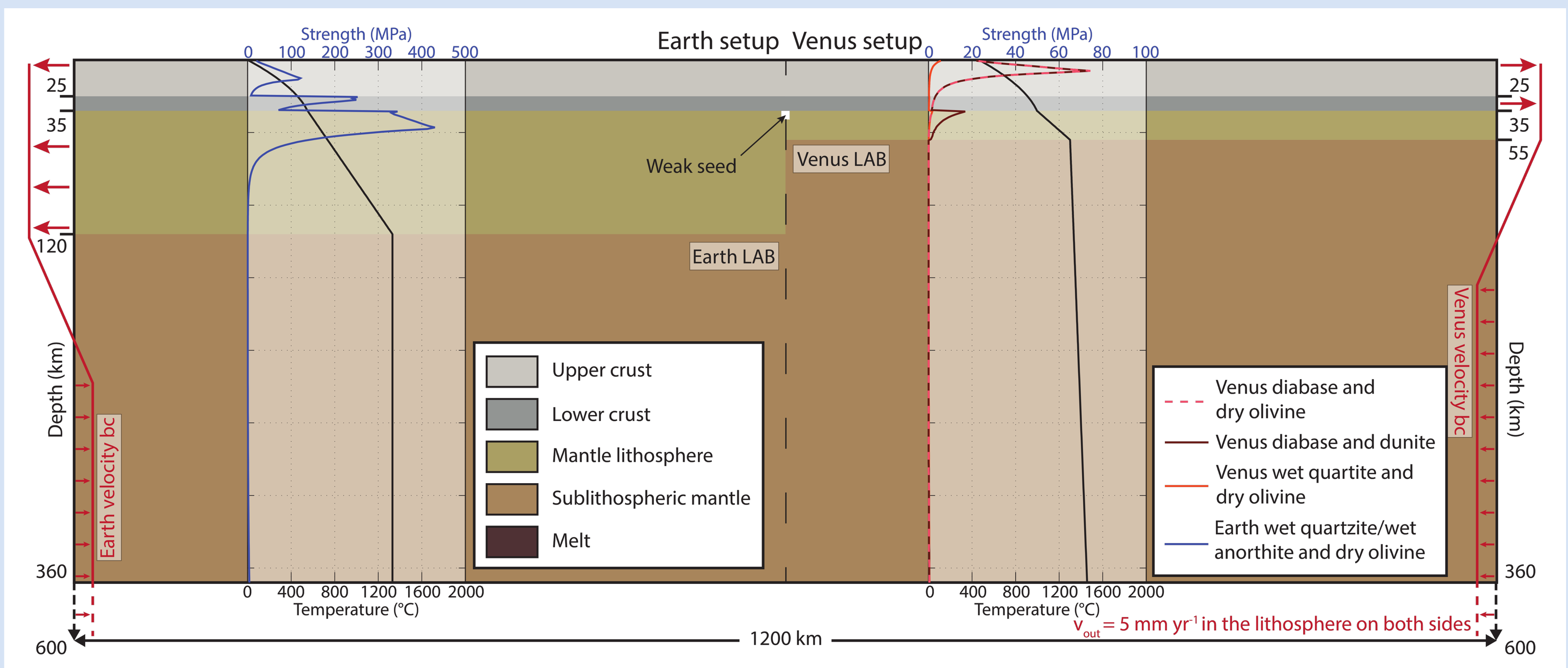
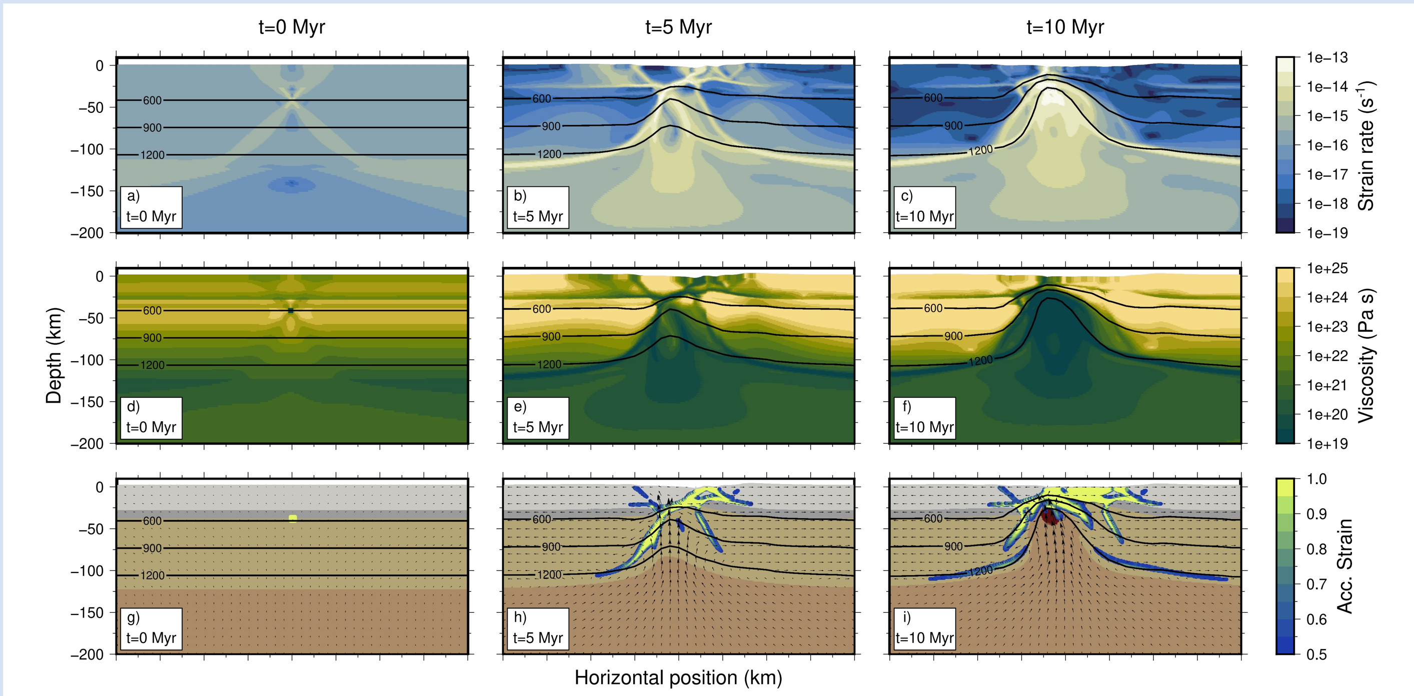
Introduction

Venus is a terrestrial planet with dimensions similar to the Earth and, although it is generally assumed that it does not host plate-tectonics, there are indications that Venus might have experienced some form of tectonics. The rifts on Venus (chasmata') have been likened to continental rifts on Earth such as the East African (e.g., Basilevsky & McGill, 2007) and Atlantic rift system prior to ocean opening (Graff et al., 2018), even if they are commonly wider than their terrestrial equivalent (e.g., Foster & Nimmo, 1996). However, despite being a prominent feature on its surface, little is known about the mechanisms responsible for creating rifts on Venus beyond the assumption that they are extensional features (Magee & Head, 1995). Here, we used the 2D numerical code FALCON adapting numerical models of rifting on Earth to Venus in order to study how rifting could have been formed and evolved under the high pressure and temperature conditions of the Venusian surface.

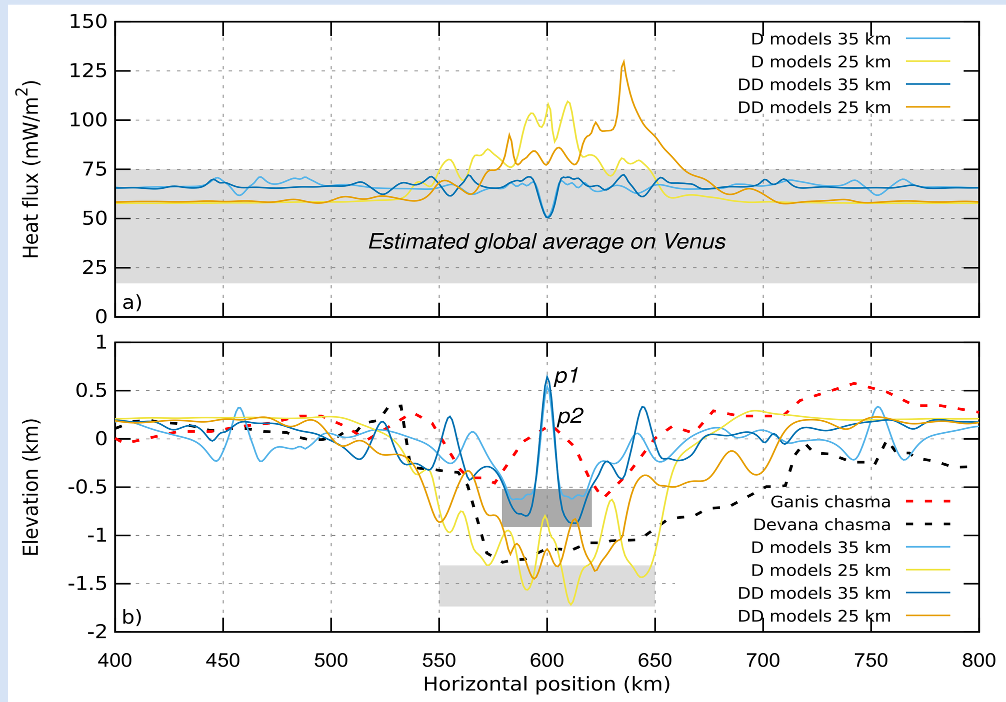
Model Setup



Earth Model

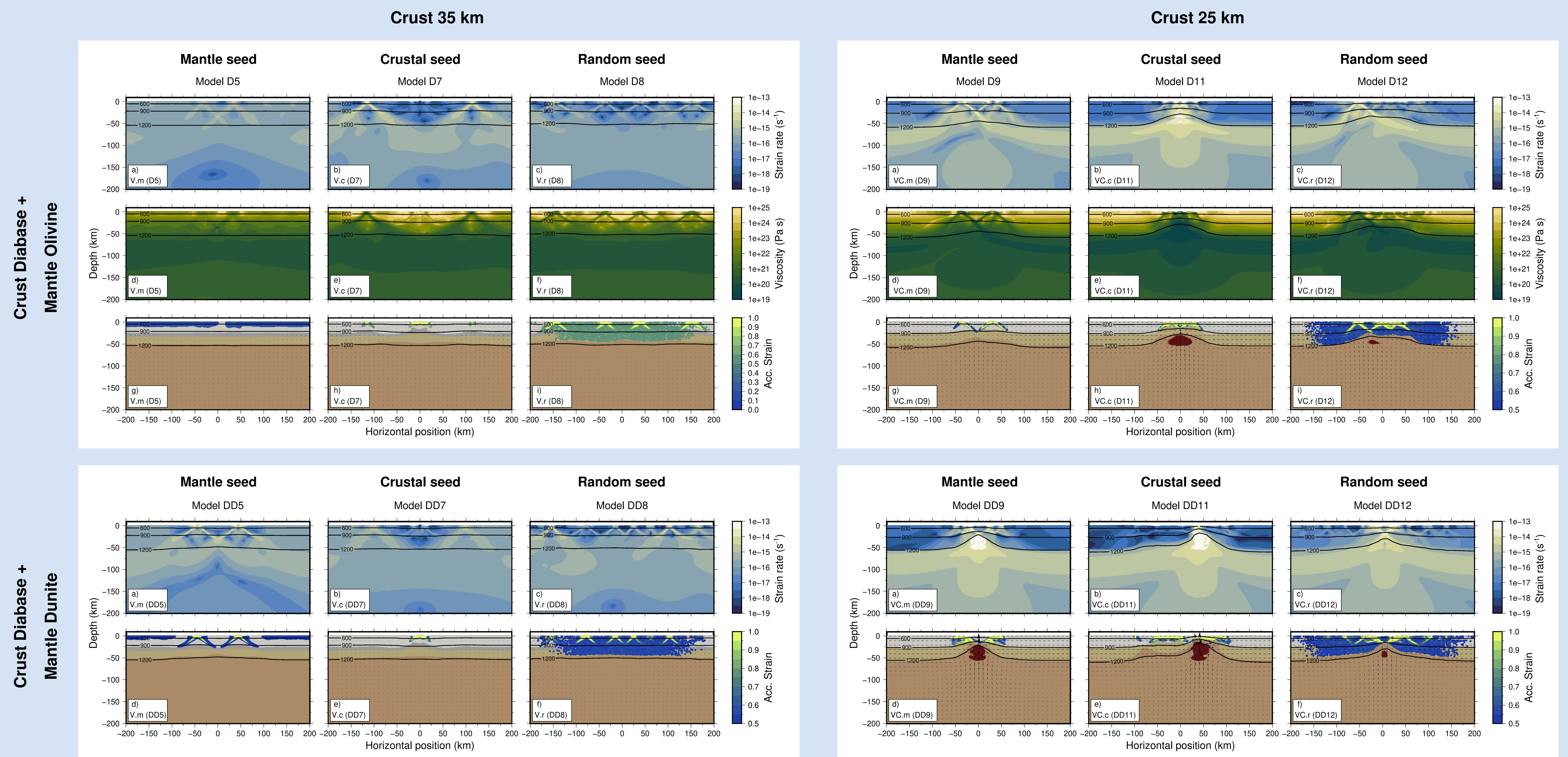


Heat flux and Elevation



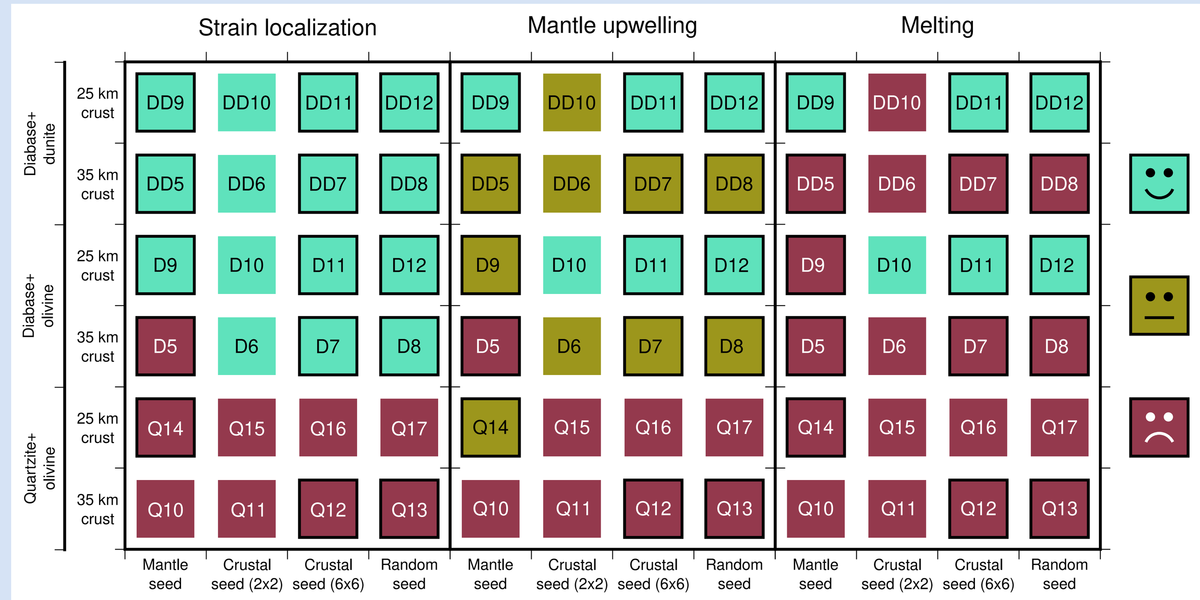
Average heat flux (panel a) and elevation (panel b) of diabase (light blue and blue lines) and diabase-dunite models (yellow and orange lines) with a 25 and 35 km-thick crust. Black and red dashed lines in panel b indicate the average topography of Ganis and Devana Chasmata. Light and dark gray areas indicate the minimum topography for the 25 and 35 km-thick crustmodels, respectively. p1 and p2 indicate the position of the peak topography for the 35 km-thick crust models and of Ganis chasma, respectively.

Venus Model



Summary of the results

Summary of the results of all of the simulations with Venus conditions. Turquoise squares indicate when strain localization, mantle upwelling, or melting occur. Olive green squares indicate that mantle upwelling occurs partially. Dark red squares indicate a lack of strain localization, mantle upwelling, or melting.



Conclusion

Our results show that a strong crustal rheology such as diabase is needed to localize strain and to develop a rift under the harsh surface conditions of Venus. The evolution of the rift formation is predominantly controlled by the crustal thickness, with a 25 km-thick diabase crust required to produce mantle upwelling and melting. Lastly, we compared the surface topography produced by our models with the topography profiles of different Venusian chasmata. We observed a good fit between models characterised by different crustal thicknesses and the Ganis and Devana Chasmata, suggesting that differences in rift feature could be due to different crustal thicknesses.

References

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