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Thermal evolution and magmatic history of Venus

Carianna Herrera[1], Ana-Catalina Plesa[1], Julia Maia[1], Stephan Klemme[2], and Lauren Jennings[2]
[1]German Aerospace Center (DLR), Institute of Planetary Research, Germany (carianna.herrera@dlr.de)
[2]University of Münster, Institute of Mineralogy

The recent analysis of radar data from NASA's Magellan mission suggests that volcanic activity is ongoing on Venus [1], providing unprecedented evidence that Venus's evolution and present day state has been dominated by volcanic processes. Venus's geodynamics and tectonics seem to be well characterized by the so-called "plutonic squishy lid" regime, where part of the melt that is formed in the interior rises to the surface but a significant part remains trapped in the crust and lithosphere forming intrusions [2]. These intrusions strongly influence the mantle's thermal evolution, heat flow, and the present-day thermal state of the subsurface.

This study focuses on the effects of intrusive magmatism on the lithosphere thickness and thermal gradient. The latter is used to evaluate our models by comparing our results to estimates based on studies of the elastic lithosphere thickness [3,4,5]. We use the geodynamic code Gaia in a 2D spherical annulus geometry [6]. Our models vary the intrusive to extrusive ratio from a fully intrusive case to a fully extrusive one and the intrusive melt depth from 10 km to 90 km.

Our models show that depending on the percentage of extrusive melt and the depth of magmatic intrusions, the maximum thermal gradient varies from a few K/km up to almost 40 K/km at present day, with higher values obtained for higher percentages of intrusive melt and shallower the magmatic intrusions. Moreover, our results show that the thermal gradients have remained similar during the last 750 Myr. Models in which the extrusive magmatism is higher than 60% and the depth of magmatic intrusions lies deeper than 50 km cannot explain high local thermal gradients as suggested by studies of elastic lithosphere thickness [3,4,5].

In a recent study [7], the presence of a low viscosity layer (LVL) in the shallow Venusian mantle has been suggested to be related to the presence of partial melt. The LVL starts beneath the lithosphere at depths shallower than 200 km. This places constraints on the depth of melting that we can use to select successful models. Models that are compatible with partial melting starting at depth of 200 km or less beneath the surface require less than 40% extrusive magmatism and an intrusive melt depth strictly higher than 10 km.

We use our models to estimate ranges for melting conditions in the interior at present day. The range of melt temperatures lies between 2000 and 2250 K and the depth of melting between ~200 and 360 km. These estimations serve as a starting point for and will be compared with high-pressure-high-temperature laboratory experiments that will be performed at the University of

Münster to select the most likely mantle compositions of Venus that can explain the Venera and Vega data.

References:

[1] Herrick & Hensley, Science, 2023. [2] Rolf et al., SSR, 2023. [3] Smrekar et al., Nature Geoscience, 2023. [4] Borelli et al., JGR, 2021. [5] Maia et al., JGR, 2022. [6] Hüttig et al., PEPI, 2013. [7] Maia et al., GRL, 2023.