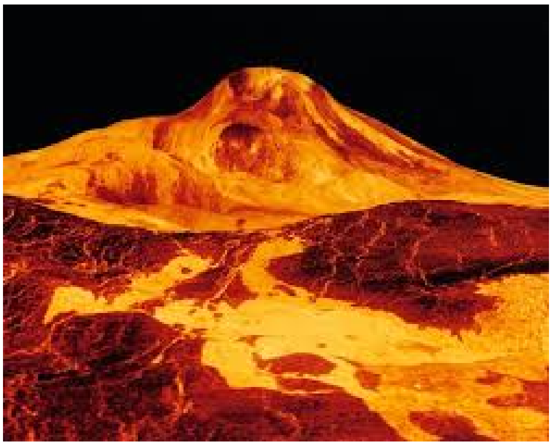
How Venus' Volcanoes Reveal the Planet's Heat Flow



SUMMARY.
Venus is commonly called Earth's evil twin due to its hellish surface conditions. Although similar in terms of mass and size to the Earth, its surface temperature is about 470°C due to a thick CO_2 dominated atmosphere. It is still unclear how such an Earth-like planet could have turned out so different. On Earth, plate tectonics dictates the global geology and efficiently cools down the planet. On Venus, plate tectonics is absent – for reasons still unclear – and the planet must have altearnative ways of expelling its internal heat. To understand the mechanism of heat loss on Venus we must constrain its surface heat flux. In this project, the student will perform new estimates of Venus heat flux over volcanic features. They will first learn the theory behind the mechanical behavior of planetary crusts and how this can be used to infer interior temperatures. Building on this knowledge, they will model the flexure (bending) of Venus' crust in response to the weight of volcanic structures and match the models to spacecraft-derived topography data to constrain the heat flow beneath these volcanic regions.

OBJECTIVES

- *The student will learn about the basic principals of crust and lithospheric dynamics and how to use analytical models to describe them.*
- *They will learn how to use geographic information system for planetary bodies (e.g. JMARS) and implement and run analytical geophysical models.*

INSTITUTE

The work will be done in the Planetary Physics Department at the Instute of Planetary Research of the German Aerospace center (DLR) in Berlin.

- German Aerospace Center (DLR)
- https://www.dlr.de/en/pf
- Rutherfordstrasse 2, Berlin

THEORY

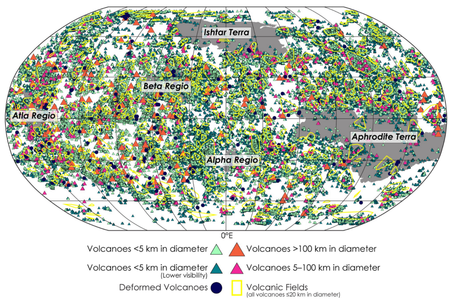
by Julia Maia

Understanding how large mountains resist gravity and remain elevated above a planet's hydrostatic shape has been a central question in geophysics for centuries. Today, it is well established that this weight is partially supported by the intrinsic strength of the crust, which in turn depends on the planet's internal temperature — the colder the planet, the stronger its crust. In planetary science, where direct measurements of a planet's internal temperature are extremely challenging, studying the so-called support mechanisms of topographic rises provides the best method for constraining a planet's internal thermal state. ***The theoretical part of this project will focus on understanding the mechanisms of topographic support and how they can be used to estimate a planet's interior temperature and surface heat flow.***

APPLICATIONS

by Julia Maia

The recent database of Volcanoes on Venus by Hahn and Byrne (2023) has opened a new frontier for the study on volcanic features on Venus. In this project, the student will focus on investigating mid-sized volcanoes to look for signatures of crustal deflection in the topographic data. For the volcanoes with clear flexural signature, the student will create a dataset of topographic profiles extracted from data obtained by the Magellan missions. In a second step, the student will implement an analytical model of lithospheric flexure in Python. Then, they will investigate a wide range of model parameters to find those the best fit the data, allowing for the estimation of the best-fit surface heat flow.



Venus' volcanic database by Hahn and Byrne (2023) with over 80,000 volcanoes.

MAIN PROGRESSION STEPS

- `Week 1-2`: Crust and lithosphere dynamics course (mornings) and exercises (afternoons)
- `Week 3`: Tutorials on GIS + assessment of topographic profiles
- `Week 4-5`: Project. Model implementation and testing
- `Week 6-7`: Project. Modeling and heat flow estimation for selected features
- `Weeks 8-9`: Project. Wrap-up and preparation for defense

EVALUATION

- `Theory grade [30%]`
  - Written report (100%)
- `Practice grade [30%]`
  - Project (100%): initiative, progress, analysis
- `Defense grade [40%]`

– Oral and slides quality
– Context
– Project / Personal work
– Answers to questions

BIBLIOGRAPHY & RESOURCES

- O'Rourke and Smrekar 2018
- Maia and Wieczorek 2022
- Hahn and Byrne 2023

CONTACT

Julia Maia
☎ +49 30 67055 8497
✉ julia.maia@dlr.de