Venus: petrological-geophysical modelling of the crust to understand tesserae composition

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Description:
Despite being Earth's closest planetary neighbour not only in distance but also size and mass, Venus research and exploration has been impeded by surface temperatures of 464 °C, a carbon dioxide-rich atmosphere, clouds of predominantly sulphuric acid, and a surface pressure of 92 bars[1]. While Venus is not a very hospitable planet today, an early Earth-like atmosphere and even oceans have been suggested[2]. The presence of water on a planet, however, is not only relevant for habitability but also influences its geology and petrology since certain igneous rock types only form from original magma that contain water. While the majority of Venus' surface is basaltic, its highlands (or tesserae), the stratigraphically oldest and highly deformed units, have been interpreted to be composed of felsic rocks[3] implying that they could be counterparts to Earth's continents. While the composition and time of formation of tesserae are a matter of debate, they show layering which could be interpreted as volcanic and/or sedimentary deposition[4].

This project will constrain the composition and formation conditions of tesserae using a combined petrological-geophysical modelling approach while assessing the amount and role of possible water on early Venus and their influence on the evolution of the planet. The new models will also allow a comparison between Venus and Earth by characterizing the differences in crustal and planetary evolution.

In detail the project will seek to:

1) Use phase equilibria modelling (with the software package Perple_X) to compute phase diagrams for a variety of crustal rock types ranging from mafic to felsic as well as enriched and depleted mantle compositions. This will be used to investigate the temperature and pressure dependent mineralogical changes with increasing depth. Densities and seismic velocities will be extracted from the calculated phase diagrams.
2) Combine the computed physical rock properties (mineralogy, densities, and seismic velocities) with geophysical parameters such as possible geotherms relevant for Venus in isostasy and lithospheric models (1-D and/or LitMod2D_2.0) to constrain rock compositions and conditions (P-T-X_{H2O}) that would keep the tesserae buoyant.
3) Add fluids to the phase equilibria calculations and quantify the differences between predominantly dry and wet scenarios for isostasy, mineral reactions, and rock types. Compare results to the planetary evolution of Earth.

This project will pioneer a combined petrologic-geophysical modelling approach to understand the composition and evolution of tesserae and the structure of the venusian crust and upper mantle. The results will contribute to the interpretation of available emissivity data for Venus surface rocks and create a reference framework for future Venus exploration and data acquisition.

References:

1. Taylor, F.W. et al. (2018). Venus: The atmosphere, climate, surface, interior and near-space environment of an earth-like planet. Space Science Reviews, 214:25.
2. Way, M.J. et al. (2016). Was Venus the first habitable world of our Solar System? Geophysical Research Letters, 43: 8376-8383
3. Hashimoto, G.L. et al., (2008). Felsic highland crust on Venus suggested by Galileo near-infrared mapping spectrometer data. Journal of Geophysical Research, 113, E00B24.
4. Byrne, P. K. et al. (2020). Venus tesserae feature layered, folded, and eroded rocks. Geology, 49, https://doi.org/10.1130/G47940.1

Qualifications required:

A degree in Earth Sciences or equivalent with strong background in petrology and mineralogy and interest in modelling.