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# Venus' interior structure and dynamics

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## Abstract

The information that the mission Venus Express has collected for a better understanding of Venus' interior structure and dynamics is limited. However, during the lifetime of this mission, models of the interior dynamics of a terrestrial-type planet have progressed. This paper reviews the models that have been developed in order to understand why the two sister planets Earth and Venus are so dramatically different. The relationship between mantle convection and plate tectonics deserves particular attention. This question is triggered by the discovery of terrestrial exoplanets that raises the issue of whether they are Earth-like or Venus-like.

## 1. Introduction

The evolution of the Earth's twin sister is still puzzling and one keeps wondering why two planets so similar in size and mass have evolved so differently with one being habitable. Is the distance to the Sun the only explanation? Why mantle convection leads to mobile lid regime, i.e. plate tectonics, on Earth and stagnant lid regime on Venus? Did Venus change convection regime in the past? Is Venus active today as suggested by VIRTIS emissivity values on volcanic domains [1]? Our current understanding of the interior structure is first described before addressing the interior dynamics from both a numerical approach and a laboratory approach.

## 2. Interior structure

Several data sets have used to infer some information on the interior structure. First, the analysis of the topography and the gravity field provides information on the elastic thickness of the outer layer. The lack of magnetic field suggests that the heat-flux at the core/mantle boundary is small or that the core is solid, a result that is difficult to reconcile with a thermal evolution without plate tectonics (see Section 3). If volcanism happens on Venus, then it places constrains on the temperature gradient since the temperature has to be larger than the mantle temperature of mantle rockes for partial mels to be generated.

## 3. Interior dynamics – numerical models

With the progress in computing power, more realistic models have been proposed to describe mantle convection in Venus interior. Models taking into account complex rheology, spherical shape, depth-dependent thermal parameters have been developed. The most critical parameter is viscosity which is temperature and pressure dependent but also varies with the presence of water. Finally, models that include deformation of the lithosphere and the possible formation of plates are described to show the differences between a stagnant lid and a mobile lid convection.

This chapter will also address the use of scaling laws to describe Venus' thermal evolution.

A chapter will be devoted to the magnetic field in slowly rotating spheres and it will be shown that the most plausible explanation for the lack of magnetic dynamo is the small heat flux at the core/mantle boundary.

Finally, models of partial melt and its migration to the surface will be described. Such models can provide key information on the volatile species being outgassed.

## 4. Interior dynamics – the laboratory inputs

This chapter describes laboratory experiments on several aspects of the interior dynamics, including fluid convection in tanks, magnetic dynamos is a

slowly rotating sphere, and migration of melt when the surface pressure is large.

## 5. Discussion and conclusions

The discussion focuses on several aspects of Venus evolution: (i) did plate tectonics operate on Venus in the past, (ii) how much water may be contained in Venus mantle, (iii) how important is the Earth-Venus paradox in the context of terrestrial exoplanets.

As a conclusion, the paper describes some measurements that would help constrain the interior structure, the interior dynamics and the evolution of Venus.

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## References

[1] Smrekar, S.E. et al., Recent Hotspot Volcanism on Venus from VIRTIS Emissivity Data, Science, 328, 605, 2010.