The Evolution of Venus and its Late Accretion

Cedric Gillmann*†1, Gregor Golabek[2], Sean Raymond[3], Paul Tackley[4], Maria Schönbächler[5], Veronique Dehant[6], and Vinciane Debaille[7]

[1]Université libre de Bruxelles – ULB, 50 Avenue F.D. Roosevelt, B-1050 Bruxelles Laboratoire G-Time, Belgium

[2]Universität Bayreuth – 95440 Bayreuth, Germany

[3]Laboratoire d'Astrophysique de Bordeaux – CNRS : UMR5804 – France

[4]Institut für Geophysik (ETHZ) – ETH Zürich, Sonneggstrasse 5, Zürich, CH-8092, Switzerland, Switzerland

[5]Institute for Geochemistry and Petrology, ETH Zurich (IGP [ETH-Z]) – CH 8092, Zurich, Switzerland

[6]Royal Observatory of Belgium (ROB) – Royal Observatory of Belgium Ringlaan-3-Avenue Circulaire B-1180 Brussels, Belgium

[7]Département des Géosciences, Environnement et Société, Université Libre de Bruxelles (ULB) – Avenue FD. Roosevelt, 50 1050 Bruxelles, Belgium

Abstract

Venus shares some striking similarities with Earth; at the same time, it exhibits characteristics that are widely different from that of our own planet. Indeed, it is an example of an active planet that followed a radically different evolutionary pathway despite the similar mechanisms at work and probably comparable initial conditions. Understanding Venus' evolution might be a key to our comprehension of how a planet can become or cease to be habitable.
We have been developing a coupled numerical simulation of the evolution of Venus, striving to identify and model mechanisms that are important to the behaviour of the planet and its surface conditions. Currently the simulations include modelling of mantle dynamics, core evolution (magnetic field generation), volcanism, atmospheric escape (both hydrodynamic and non-thermal), evolution of atmosphere composition, and evolution of surface conditions (greenhouse effect) and the coupling between interior and atmosphere of the planet. We have also modelled the effects of large meteoritic impacts on long term evolution through three aspects: atmosphere erosion, volatile delivery and mantle dynamics perturbation due to energy deposition.

Volatile fluxes between the different layers of the planet seem critical to estimate how Venus changed over time. This is especially important as we have highlighted the strong role played by mantle/atmosphere coupling in regulating both mantle dynamics and surface conditions through surface temperature evolution. Mantle convection regime evolves with time and depends on surface conditions. We produce scenarios that fit present-day conditions and feature both early mobile lid regime (akin to plate tectonics) as well as late episodic lid regime with resurfacing events. The early history of Venus, in particular, seems to have

*Speaker

†Corresponding author: cgillman@ulb.ac.be

large repercussions on its long term evolution and present-day state, as it determines volatile inventories and repartition.
It is therefore critical to investigate impacts that affect the evolution of Venus during the Late Accretion era. While the atmosphere erosion they generate doesn't deplete the atmosphere as much as swarms of smaller bodies, they instead act as a significant source of volatiles. Indeed, if Late Accretion is mainly composed of volatile-rich bodies, it is very difficult to reach the observed present-day state of Venus; instead the atmosphere may become too wet. Simulations show wet material (carbon chondrites) contribution limit at a maximum of 5-10% (mass.) of the total accreted mass during Late Accretion (the larger portion of the Late accretion being composed of enstatite chondrite bodies). Large impacts also affect mantle convection, modifying convection patterns for millions of years. Finally, the more energetic collisions (impactors with radii in the 100s of km, high velocity) generate massive melting events near impact location, associated with large scale degassing of the mantle. This leads to mantle depletion and can potentially leave (at least) the upper mantle of the planet dry, with strong consequences for later evolution.