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Late Veneer collisions and their impact on the evolution of Venus (PS Division Outstanding ECS Award Lecture)

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During the end of the accretion, the so-called Late Veneer phase, while the bulk of the mass of terrestrial planets is already in place, a substantial number of large collisions can still occur. Those impacts are thought to be responsible for the repartition of the Highly Siderophile Elements. They are also susceptible to have a strong effect on volatile repartition and mantle convection.

We study how Late Veneer impacts modify the evolution of Venus and its atmosphere, using a coupled numerical simulation. We focus on volatile exchanges and their effects on surface conditions.

Mantle dynamics, volcanism and degassing processes lead to an input of gases in the atmosphere and are modeled using the StagYY mantle convection code. Volatile losses are estimated through atmospheric escape modeling. It involves two different aspects: hydrodynamic escape (0-500 Myr) and non-thermal escape. Hydrodynamic escape is massive but occurs only when the solar energy input is strong. Post 4 Ga escape from non-thermal processes is comparatively low but long-lived. The resulting state of the atmosphere is used to the calculate greenhouse effect and surface temperature, through a one-dimensional gray radiative-convective model.

Large impacts are capable of contributing to (i) atmospheric escape, (ii) volatile replenishment and (iii) energy transfer to the mantle. We test various impactor compositions, impact parameters (velocity, location, size, and timing) and eroding power. Scenarios we tested are adapted from numerical stochastic simulations (Raymond et al., 2013). Impactor sizes are dominated by large bodies (R>500 km).

Erosion of the atmosphere by a few large impacts appears limited. Swarms of smaller more mass-effective impactors seem required for this effect to be significant. Large impactors have two main effects on the atmosphere. They can (i) create a large input of volatile from the melting they cause during the impact and through the volatiles they carry. This leads to an increase in atmosphere density and surface temperatures. However, early impacts can also (ii) deplete the mantle of Venus and (assuming strong early escape) ultimately remove volatiles from the system, leading to lower late degassing and lower surface temperatures. The competition between those effects depends on the time of the impact, which directly governs the strength of atmospheric losses.