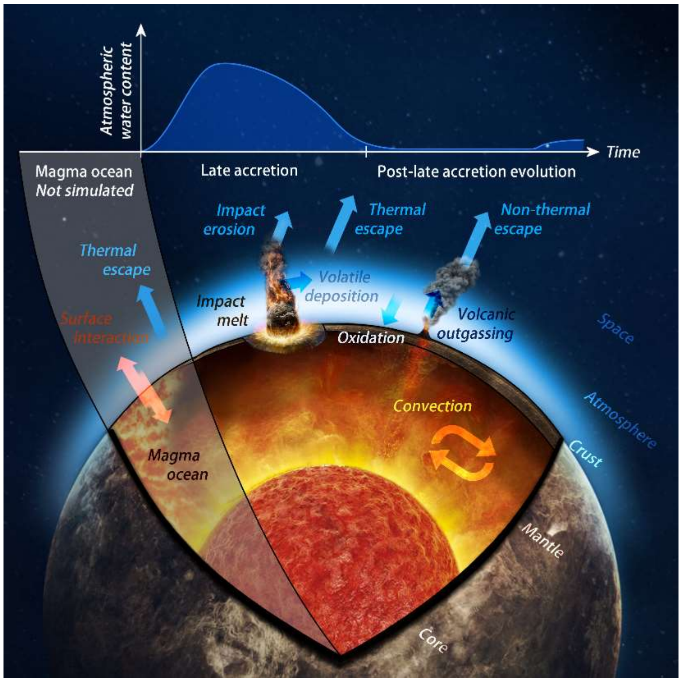
Press release “Dry late accretion inferred from Venus’s coupled atmosphere and internal evolution”

by C. Gillmann, G. J. Golabek, S. N. Raymond, M. Schönbächler, P. J. Tackley, V. Dehant & V. Debaille;

published April 7 in Nature Geosciences



What is the origin of water on Earth?

While everybody agrees that our blue planet is rich in water, this observation is at odd, first, with the exploration of other rocky planets, genuinely lacking surface water, and second, with the idea of a giant impact between the proto-Earth and a planetary embryo the size of Mars that created the Moon. Such a catastrophic event should have vaporized any pre-existing water, leaving behind a dry Earth. After the giant impact catastrophe, we have thus two options to explain the presence of water on Earth:

- either water was brought back later, after the catastrophe, notably by icy or water-rich asteroids,

- or the giant impact was not big enough to vaporize all the water on Earth.

Because of the importance of water to sustain life, the question of the origin of water on Earth is primordial. A major challenge in investigating this question is that Earth has lost all the traces of its formation since it is an active planet.

A team of numerical modelers and geochemists led by Cédric Gillmann (ULB, funded by the EoS project ET-HoME) has decided to look far beyond Earth - up to Venus - to investigate the origin of terrestrial water. While Earth and Venus could be considered as twin sisters, their respective geological and climatic evolutions diverged dramatically in the past, leading to Venus' present-day 92 bar atmosphere heated by an infernal greenhouse up to 740 K, opposed to the mild conditions and only 1 bar pressure at the surface of Earth. However, Venus' volcanic activity and outgassing are reduced compared to Earth, because it has no plate tectonics, but has a stagnant lid instead. Even better, such a convection mode implies very little recycling of volatile species into the mantle. As such, despite being an inferno, the evolution of the atmosphere of Venus is much easier to understand and model over geological times. In addition, because of their proximity, the Earth and Venus should have received the same type of material during their history. All these aspects combine to make Venus a perfect place to study the primitive evolution of terrestrial planets.

Thanks to numerical simulations of impacts of different types of asteroids containing various amount of water, the team has discovered that water-rich asteroids colliding with Venus and releasing their water as vapor cannot explain the composition of Venus atmosphere as we measure it today. It means that the asteroidal material that came to Venus, and thus to Earth, after the giant impact must have been dry, therefore preventing the replenishment of the Earth in water. Because water is obviously here today, it means that the water we are now enjoying on Earth has been there since its formation, likely buried deep in the Earth so it could survive the giant impact.

This idea has very deep implications in terms of habitability of ancient Earth, Venus and Mars, as it suggests that planets likely formed with their near-full budget in water, and slowly lost it with time. Because Mars is much smaller, it likely lost all its water while life developed on Earth. For Venus, those results shine a complementary light on recent work advocating that water oceans existed at the surface of the planet, and help constrain the maximum amount of water that can be expected on Venus. They will also help prepare the next generation of space missions to Venus.

The EoS project ET-HoME is a joint funding between the Belgian FWO and FNRS, that gathers the expertise of 7 partners, two having participated to this study: Université Libre de Bruxelles (Cédric Gillmann; Vinciane Debaille) and Université Catholique de Louvain (Véronique Dehant). This research also built upon the IUAP "Planet-Topers" led by the Royal Observatory of Belgium.