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Water and the tectonic regime of Venus

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Observations of Venus imply ongoing tectonic and volcanic activity, suggesting the planet is dynamically active[1,2]. Tectonically altered regions, such as ridges or tesserae, indicate surface mobility. However, unlike Earth, no evidence of active plate tectonics has been identified. The tectonics and volcanism of terrestrial planets are closely tied to active mantle convection modes. Rheology, a crucial element in tectonics, is influenced by the presence of water[3]. Despite this, the impact of water has largely been overlooked in Venus studies, as its interior is typically assumed to be dry. This assumption is being challenged by indications of significant hydrodynamic escape into space, requiring volcanic replenishment. Consequently, water is likely still present in Venus' interior, even if the concentrations are unknown. Importantly, the potential effects of water on Venus' dynamics and evolution remain poorly understood. The interplay between water, mantle dynamics, and volcanic activity would likely contribute to a more comprehensive understanding of Venus' evolution. This underlines the need to consider complex dynamic thermo-magmatic models that account for water, including composition-dependent finite water solubilities.

In this study, we use the numerical code StagYY to perform state-of-the-art 2D models in a spherical annulus geometry to assess the effects of water on the tectono-magmatic evolution of Venus[4,5]. Particular attention will be given to the way water influences mantle convection and tectonics. Indeed, results show that the presence of water can dramatically change the geodynamic regime through the rheology, melting and outgassing. With the introduction of composition-dependent water solubility maps, dehydration processes will redistribute water throughout the mantle[6]. Since water content is directly related to the viscosity structure, the convective regime is expected to change as well. The main question we want to address is how dehydration processes and water distribution influence the convective and tectonic regimes of Venus. Studying the impact of water on Venus's interior may not only unveil insights into its tectonic evolution but also sets the stage for crucial future research, advancing our broader understanding of planetary processes and habitability.

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