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1D Modeling of the Magma Ocean Stage of Rocky Planets

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To better understand the evolution of rocky planet interiors and their redox transformations, we are developing a comprehensive 1D mineralogical and geochemical interior model. This model is designed to simulate the initial conditions and subsequent evolution of rocky planet interiors in the magma ocean stage.

This project creates a 1D grid-based compressible interior-structure model with a magma ocean thermal evolution and solidification model, building upon existing codes and models [1]. Differing from previous magma ocean models, this 1D model incorporates the evolution of core differentiation and couples it with a magma ocean model. We also further enhance previous models by incorporating depth-dependent thermodynamic properties and implementing high-temperature and high-pressure melt Equations of State (EOS). We are developing a composition-dependent melting temperature formulation that aligns with low-pressure melting temperature laws. For the high-pressure environments of planetary interiors, we apply the extended Lindemann-Stacy melting law [2]. Moreover, the early planet accretion stage is considered in this model and different accretion scenarios are investigated.

Our approach is expected to provide thermal and chemical profiles from planet formation till the end of the magma ocean stage. Our results will help determine the efficiency of core formation under different redox states and planetary conditions during the magma ocean stage. In the future, the results of this model could also be used as inputs for 2D convection simulations or planetary atmospheric models.

References

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