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Influence of mantle composition on convection and melting processes

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Thousands of exoplanets have been discovered in the past decade, revolutionizing our way of scientific thinking both in the direction of formation and evolution of planets, as well as in the direction of exotic places where life may evolve and flourish in non-Earth-like environments. However, identification of possible atmosphere biosignatures or models of the evolution of exoplanets are typically based on Earth models - which is a natural first step to understand processes on possibly habitable planets, especially since we are more prone to detect exo-life (if it exists) on Earth-like planets than on other planets due to our detection bias.

Several studies for example extrapolated Earth models to other planet properties (e.g. mass, radius, core size) to predict how basic planetary processes (like mantle convection or plate tectonics) are affected by these parameters. However, even if a planet is discovered with a density hinting at a rocky planet, it may be quite non-Earth-like for example in terms of composition, mineralogy, core formation, volatile content, etc. Within the range of uncertainties and with the current observation techniques, it is impossible to differentiate remotely between a planet like Earth with continents and oceans at the surface, or a dry one-plate planet, or an ocean planet, or exotic planets like carbon-rich ("diamond") planets.

It is therefore necessary to study how the evolution of a planet may be affected by the unknown planet's properties as well as its formation and evolution history, and to understand better possible restrictions for surface or subsurface habitability. The composition of the mantle has a strong influence on the mantle convection (and possibly plate tectonics initiation or maintenance), as well as on the crust and atmosphere evolution. Water and iron content both have a strong influence on the rheology of the mantle as well as melting temperatures and melt density (and hence buoyancy).

Stochastic Monte-Carlo models of possible planet post-formation-states and compositional variations are used in this study to predict the range of possible evolution trends for rocky planets.