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Propensity of Plate Tectonics on Super-Earths: Influence of Pressure

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On Earth, plate tectonic recycles carbon, stabilizes the atmosphere, cools the interior and helps to maintain a magnetic field. It therefore may be an indicator for habitability of a planet.

The simulation of convection and plate tectonics on Super-Earths is very cost-intensive for a realistic parameter range and often leads to numerical errors. For this study, we therefore define an Earth-like reference planet and then vary parameters such as reference viscosity or mantle thickness to investigate the effect on the propensity of plate tectonics, i.e. if a planet is more or less likely to have plate tectonics than Earth. It can be shown that the interaction between the parameters plays an important role: For example, an increase of the non-dimensional yield stress due to an increase of planetary mass would lead to a stagnant lid rather than plate tectonics. However, if the mass (radius) of a planet is increased, the Rayleigh number increases as well, which would favour plate tectonics. A higher reference viscosity on the other hand leads to a smaller non-dimensional yield stress, and plate tectonics is more likely. Note, however, that there is a threshold in the reference viscosity, i.e. with further increasing the reference viscosity plate tectonics is again less likely.

In addition to the parameters mentioned above, we examine the pressure effect on the viscosity and its influence on the mantle dynamics. So far, this has been neglected in earlier studies about plate tectonics on Super-Earths [1; 2]. Pressures higher than in the Earth's mantle can result in very high viscosities [3] and mantle flow in the lower mantle of Super-Earths may become very sluggish or even stagnant. A reduction of the convective vigour leads to smaller convective stresses below the lid and hence plate tectonics is less likely.

The study of the propensity of plate-tectonics on Super-Earths, therefore, depends on the combination of relevant parameters and we investigate the effect of every single parameter as well as the combination of these. Our preliminary results indicate that the propensity of plate tectonics has a peak at a mass of slightly more than one Earth mass. Considering further that in general a planet is cooling and mantle temperatures decrease in time, it can be shown that the propensity of plate tectonics may have an additional peak during the thermal evolution. Thus, the propensity seems to be highly dependent on time (i.e. temperature) and mass of a planet. Plate tectonics hence may occur more seldom than previously thought.

[1] Valencia, D.; R.J. O'Connell, and D.D. Sasselov (2007): Inevitability of Plate Tectonics on Super-Earths. Astrophysical Journal 670, L45-L48.
[2] O'Neill, C. and A. Lenardic (2007): Geological consequences of super-sized Earths. GRL 34, L19204.
[3] Stamenkovic, V.; D. Breuer, and T. Spohn (2010): Thermodynamic properties, melting temperature and viscosity of the mantle of Super-Earths. AGU Fall Meeting 2010, abstract P21A-1582.