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# Habitability of Super-Earths

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## Abstract

The last 15 years of astronomical observation have shown a universe consisting of planets spanning a wide range of masses. The observational techniques offered the possibility to especially detect Super-Earths, with until now only a small fraction of them being in the range of 2-10 Earth masses. Next generation telescopes such as Kepler and improved techniques in radial velocity measurements will lower this limit and make it possible to detect even Earth-sized planets in the near future. Based on these observations it is only a natural question to ask how planetary size, structure and composition influence the habitability of planets. We especially focus on the ability of Super-Earths with sizes ranging from 1-10 Earth masses to generate a magnetic dynamo and initiate plate tectonics – both features being possibly closely linked to the habitability of the planet. The results presented here are derived from 1D parameterised thermal boundary layer models but were recently backed up by numerical 3D simulations [1]. Lately [2, 3] studied the effect of planetary mass on the ability to break plates and hence initiate plate tectonics - but both derived results contradictory to the other. We think that one of the reasons why both studies [2, 3] are not acceptable in their current form is partly due to an oversimplification. Both treated viscosity only temperature-dependent but neglected the effect pressure has on enlarging the viscosity. More massive planets have therefore a stronger pressure-viscosity-coupling. We observe that a conductive lid (termed low-lid) forms above the core-mantle boundary and thus reduces the effective convective part of the mantle when including a pressure-dependent term into the viscosity laws as shown in [1]. This changes the scaling laws for parameterized models and influences the scaling of stresses associated with breaking of plates and thus the initiation of plate tectonics. The results indicate that convective stresses remain similar while plate thicknesses increase reducing the ability of plate tectonics on Super-Earths contrary to [2]. On the other hand we also investigate the effect of planetary mass on the generation of a magnetic dynamo. The low-lid insulates the core and thus affects the growth of an inner core. This on the other hand influences the generation of a magnetic dynamo. The results depend on the melting curve, which can differ strongly in magnitude if different approaches are followed ([4], [5]). But we can show that thermodynamic constraints lead to the exclusion of [4] and therefore leave [5] as the most reliable melting curve – which we have used in our model. Assuming an initially molten core we obtain that in the early evolution the low-lid has still a strong effect on reducing the heat flow through the core-mantle-boundary even though the melting temperatures (and thus the core temperatures), are very high - up to 25’000K for 10-Earth-mass planets. We show that the mass-richer the planet, the more difficult it is to grow an inner core efficiently - hindering long-lasting dynamo action – and thus endangering a long-lasting protection of the surface by a magnetic field.

Concluding, we do observe a strong connection between planetary mass and the ability to initiate plate tectonics, and to generate a magnetic field on Super-Earths.

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