Mantle convection, stagnant lids and plate tectonics on super-Earths

PAUL J. TACKLEY AND HEIN VAN HECK

Institut für Geophysik, ETH Zürich, 8092 Switzerland (ptackley@ethz.ch)

The discovery of extra-solar super-Earths has prompted interest in their possible mantle dynamics and evolution, and in whether their lithospheres are most likely to be undergoing plate tectonics or be stagnant lids. Unfortunately the origin of plate tectonics on Earth is poorly understood, which makes it impossible to make reliable predictions for other planets. Nevertheless, as a starting point it is common to parameterize the complex processes involved as a simple yield stress that is either constant or has a linear "Byerlee's law" dependence on pressure (e.g., [Tackley, GCubed 2000ab] in 3D cartesian geometry; [van Heck and Tackley, GRL 2008] in 3D spherical geometry). For such a simple description, scaling with planet size is expected to depend on heating mode (internal versus basal) and lithospheric strength profile. Simple scaling laws (e.g., Moresi and Solomatov, GJI 1998) suggest that the threshold for plate tectonics (i.e., yield stress or friction coefficient) does not depend strongly on planet size, and plate tectonics is equally likely or more likely for larger planets.

Because the simplifying assumptions made in developing analytical scalings may not be valid over all parameter ranges, numerical simulations are needed. Here we present new calculations of convection with yielding-induced plate tectonics for varying planet size, focusing on the idealized endmembers of internal heating or basal heating as well as different yield strength profiles, and compare results to analytical scalings. Results verify the analytical prediction that plate tectonics is equally likely or more likely on larger planets, although the details (e.g., power-law exponents) are somewhat different than predicted.

In Earth, physical properties such as density, thermal expansivity, thermal conductivity and viscosity change strongly with pressure so that their values change substantially between the surface and the CMB, and many modelling studies have shown that this has a strong effect on convection. On super-Earths this will be even more pronounced. Thus, in a second set of calculations, we include reasonable variations of physical properties with pressure for planets up to twice Earth radius, and show that they have a strong effect on convection.

Advanced argillic alteration in the Karkas Mountain, Central Iran

B. TAGHIPOUR[1]*, F. MOORE[2] AND M.A. MACKIZADEH[3]

[1]Department of Earth Sciences, College of Sciences, Shiraz University, Shiraz, Iran (*correspondence: goharrr@yahoo.com)

[2]Department of Earth Sciences, College of Sciences, Shiraz University, Shiraz, Iran (moore@susc.ac.ir)

[3]Department of Geology, Esfahan University, Esfahan, Iran (ma_mackizadeh@yahoo.com)

Karkas Mountain is located 85 kilometers North of Isfahan city in Central Iran. The study area exposes a sequence of Cenozoic magmatic rocks of calc-alkaline series. This sequence is a part of a long volcano-plutonic belt in Iran (Uroumia-Dokhtar Volcanic Belt). Some hydrothermal alterations occur in the volcanics of the study area. In northern parts of area there is a thick and widespread sequence of volcanic and pyroclastic rocks with some tuffaceous sediments, which builds up the Karkas Mountain. Some volcanics in this area are subjected to hydrothermal alteration including kaolinitization and alunitization. The altered rocks are characterized by an assemblage of alunite, kaolinite and quartz, which is typical of advanced argillic alteration. Geochemical results suggest that the alunite is a solid solution between alunite [$K\ Al_3\ (SO_4)_2\ (OH)_6$] and natroalunite [$Na\ Al_3\ (SO_4)_2\ (OH)_6$]. The alunite formed at a higher temperature is usually high in sodium content [1]. These samples also contain minor amounts of P_2O_5 .The occurrence of phosphate and/or aluminum - phosphate in the fine grained alunite is a unique attribute of advanced argillic alteration in a magmatic hydrothermal environment [2] (Rye and Beth lce 1992). Mineralogical study suggests that the hydrothermal alteration in this area occur in a magmatic hydrothermal environment.

[1] Stoffregen (1987) *Econ. Geol.* **82**, 1575-1591. [2] Rye & Bethke (1992) *Econ. Geol.* **87**, 225-262.