PLATE TECTONICS OR NOT: LITHOSPHERIC STRESS ON TERRESTRIAL PLANETS AND SUPER-EARTHS. C. J. O'Neill[1] , A. Lenardic[2] and A. M. Jellinek[3], [1]GEMOC, EPS, Macquarie University, Sydney, NSW, 2109, Australia (coneill@els.mq.edu.au), [2]Department of Earth Science, Rice University, Houston, Texas, [3]Department of Earth and Ocean Science, University of British Columbia, Vancouver, Canada.

Introduction: We investigate the role of mantle-induced lithospheric stress on terrestrial planets as a function of radius and Rayleigh number. Plate tectonics minimally requires that the stress state of the lithosphere exceed some critical value - the yield stress - enabling plate failure and boundary layer recycling.

Both mantle-generated stresses, and lithospheric strength, will scale with planetary radii, and we investigate the interaction between these factors with scaling theory and numerical models of mantle convection.

Scaling theory: The driving forces for lithospheric deformation essentially arise from viscously induced mantle stresses, which scale as

$$\tau_{xz} = \frac{v_x \eta}{\delta_{vel}}$$

where v is a velocity scale, η the viscosity of the active, viscously deforming lithosphere, δ_{vel} the velocity boundary layer thickness.

Plate resistance is determined by the maximum sustainable stress at the brittle-ductile transition (BDT), which is determined by a Byerlee-style yield criterion:

$$\tau_{yield} = C_0 + \mu P$$

where C_0 is the cohesion, m the coefficient of friction, and P the pressure. While the BDT is a function of the thermal boundary layer thickness, and thus decreases with Ra, the yield strength with increase with greater pressures under the high-gravity regime of super-sized Earths. Equating these terms allows an investigation of the transition from intact to failed lithosphere over a range of Ra and planetary radii [1].

Numerical models: We use a finite-element mantle convection code with lagrangian intergration points to explore the viscous coupling and stress scalings of terrestrial planets for a variety of planetary radii. The details of the model are more thoroughly outlined in [2]. The model shown in Figure 1 is for whole mantle convection without phase transitions, or depth-dependent properties except for a viscosity increase with depth of 30.

We find increased planetary radii, and thus gravity, acts to increase mantle induced stresses, through increased Ra and buoyancy forces, and thus enhanced sublithospheric velocities. However, the integrated lithospheric strength tends to also increase, due to an incraesed strength of faults under the higher gravity and thus higher pressure regime of super-sized Earths. Our numerical models show that the latter - enhanced lithospheric strength - is the dominant factor in determining the tectonic regime for increasing planetary radii, and seem to suggest stagnant lid convection is a common tectonic endmember for super-sized Earths.

While many other factors, such as phase changes, viscosity profiles, thermal structure and internal heat production, are also first order effects, these results illustrate the competing dynamics and the potential complexity of tectonics endmembers in our catalogue of exosolar planets.

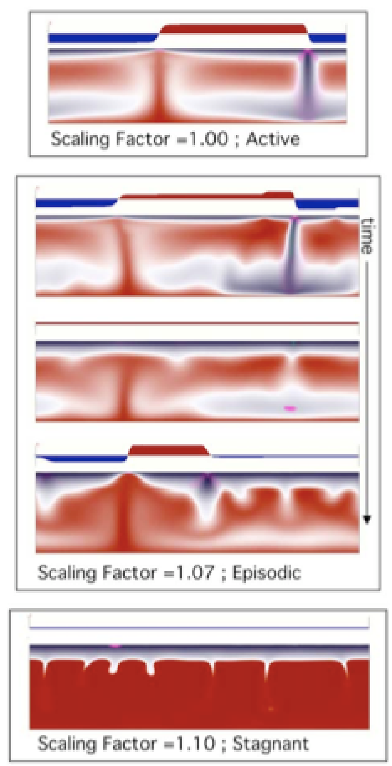

Figure 1. Variation in tectonic regime from active to stagnant for increased scaling factor (equivalent to planetary radius).

References: [1] O'Neill, C. J., Jellinek, A. M. and Lenardic, A. (2007) *EPSL, 261,*20-32. [2] O'Neill, C. J. and Lenardic, A. (2007) *GRL., 34, L19204,* doi:10.1029/2007GL030598.