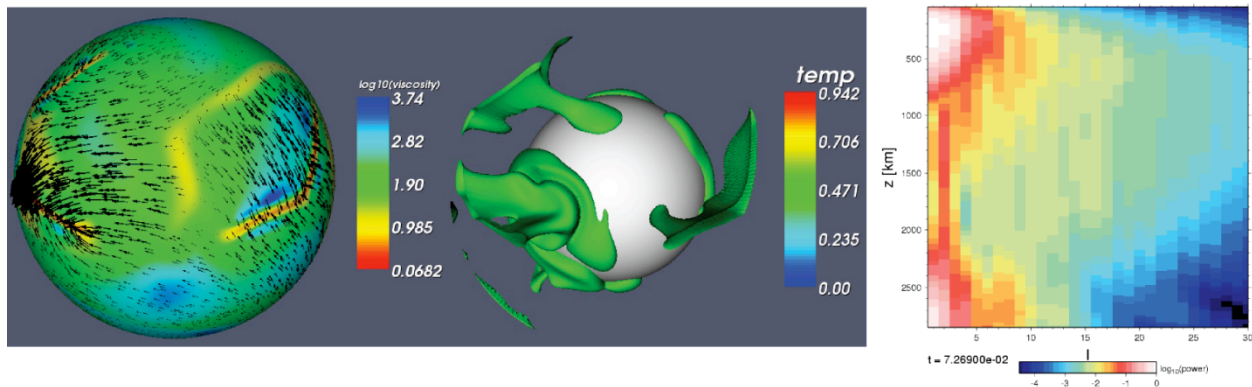


## Generation of Plate Tectonics and Mantle Heterogeneity from a Spherical, Visco-plastic Convection Model

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How plate tectonics arises from mantle convection is a question that has only very recently become feasible to address with spherical, visco-plastic computations. We used *CitcomS* to compute convection simulations with temperature-dependent viscosity, a plastic yield stress, and varying heating modes. This rheology has been shown to be effective in producing some key features of plate tectonics in 3-D Cartesian geometry: a rigid surface forms, with deformation localized in narrow zones; downwellings are sheetlike; and surface motions are coherent and uniform across ‘plates.’ We explore the Rayleigh number ( $Ra$ ) - yield stress ( $\sigma_y$ ) phase space, and the effects of depth-dependent  $\sigma_y$ , bottom heating, and a low viscosity asthenosphere.



**Figure:** Images of the surface viscosity field, with velocity vectors (left), cold isosurface showing downwellings (center), and a temperature power spectrum (right) showing a strong degree two signature.

We find that visco-plastic convection in spherical geometry produces these same, plate-like features. Additionally, the convective planform and toroidal-poloidal velocity field ratio (TPR) are affected by near-surface viscosity variations. Toroidal motion is important in the Earth, comprising approximately half of the surface velocity field. We found that models that maximize lateral viscosity contrasts (i.e. have a strong surface and numerous weak zones). We observe TPR values near 0.5 for models with high  $Ra$ . Cartesian models tend to form very long wavelength convective planforms. Our models favor spherical harmonic degree one convection though models with a weaker surface viscosity form degree two patterns and reproduce tomographically observed power spectra. Furthermore, the depth-dependent  $\sigma_y$  causes convection to favor a degree two pattern. So for appropriate parameter ranges, these models approximately reproduce observations of Earth’s convective wavelength and toroidal-poloidal velocity field partitioning.

An asthenospheric viscosity reduction improves plate-like nature, as expected. Bottom heating produces strong plumes that tend to destroy plates at the surface, implying that significant internal heating may be required, both to reduce the role of active upwellings and to form a low viscosity zone beneath the upper boundary layer.

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