Modelling the coupled long-term evolution of Earth's mantle-lithosphere-core system

Mantle convection and plate tectonics are a coupled system that are responsible for driving the dynamical processes we observe on the solid Earth, including continental drift, earthquakes and volcanoes, as well as the long term thermal and compositional evolution of Earth's interior. Mantle convection also controls the heat flux extracted from the core, which determines whether Earth has a geodynamo. Thus, lithosphere, mantle and core must be treated as a coupled system in order to understand long-term Earth evolution. We perform coupled modelling of mantle and core using a 2D or 3D mantle convection model with a parameterized core. Plate tectonics is self-consistently generated by plastic yielding. Our recent models demonstrate that crustal production arising from partial melting plays a major role in facilitating plate tectonics. These models also demonstrate transitions between tectonic models as the planet cools. Considering Earth's core evolution, there is only a limited parameter range in which the heat extracted from the core is large enough at all times for a geodynamo to exist, but small enough that the core did not cool more than observed, a balance that becomes even more difficult if the core thermal conductivity is as high as recently. Our latest models treat Earth evolution from the magma ocean phase to the present day. In the early phases of system evolution the rheological transition between solid and melt plays a major role.