Geophysical Research Abstracts
Vol. 20, EGU2018-19101, 2018
EGU General Assembly 2018

Modelling the Thermo-Chemical Evolution of the Mantle from a Molten State to the Present Day

Paul Tackley (1), Ilya Fomin (1), Diogo Louro Lourenço (1,2)

(1) ETH Zurich, Institute of Geophysics, Department of Earth Sciences, Zurich, Switzerland (ptackley@googlemail.com), (2) Department of Earth and Planetary Sciences, University of California, Davis, USA

Melting has always played a key role in Earth evolution. Solidification of a magma ocean may have left the mantle compositionally stratified and may have continued as a long-lived basal magma ocean (BMO). Ongoing upper mantle/transition zone melting, perhaps associated with water and carbonate, may have caused 'internal differentiation', resulting in dense enriched products that sink. Throughout Earth's history melting in the asthenosphere has produced crust, most of which was recycled into the interior possibly segregating above the core-mantle boundary, joining enriched products from early differentiation, internal differentiation and BMO solidification to produce a Basal Melange (BAM).

We can now simulate mantle evolution from a 100% molten state (magma ocean) to the present day using the code StagYY. Following the 1-D magma ocean modelling approach of Y. Abe, dynamics occuring in regions that are mostly solid are fully resolved, while turbulent convection in regions that are mostly molten is parameterised using an effective diffusivity. The models treat fractional melting, include segregation of melt and solid, coupling to a parameterized core, and a radiative surface boundary condition with heat loss slowed by an atmosphere. We investigate and characterize the evolution of a magma ocean as a function of various uncertainties including the shape of the solidus/liquidus (controlling whether crystallization starts in the middle or at the base), melt-solid density difference, fractional vs. batch crystallization, and cooling rate. Depending on parameters, we find that the magma ocean may have solidified with a ∼uniform or a stratified composition. Solid-state convection onset before the magma ocean was completely crystallized. The core rapidly cools to the rheological transition of the mantle, making a straightforward basal magma ocean difficult to maintain. Selected cases are run for subsequent billions of years beyond the magma ocean stage to predict modern-day mantle structure.