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The influence of plate tectonics on the mixing properties of the Earth's mantle

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During the last decade an improved understanding of the physical processes in the Earth's interior has led to the acceptance of an integrated system coupling mantle convection and plate tectonics. Higher computer power and new modelling techniques are now allowing the numerical calculation of this system in a self-consistent manner [1].
While former studies concentrated on the evolution of plate-like features [2] and the dependence on rheological parameters, the present study has a more geochemical motivation. It focusses on the influence of a plate-like surface on the mixing of chemical heterogeneities in the mantle to get a deeper understanding of the observed heterogeneous structure of the mantle and the existence of chemical distinct reservoirs.
The mixing properties of isoviscous 3D time-dependent convection has already been investigated [3]. One basic finding is the existence of two different mixing time scales. Mixing inside one convective cell is rather effective and causes homogenization on the order of several 100 Ma. Mixing between different convective cells occurs on a much longer timescale, such that heterogeneities in the mantle can survive for several Ga. The main purpose of the present investigation is a comparison between findings from isoviscous convective flows and from a flow with a viscoplastic rheology that show plate-like behaviour on the surface.
We use an approach of tracer dispersal for investigation, where tracers are infinite and passive (i.e. they are not affecting the flow), and confirm the results from isoviscous flows for more complex rheologies. In both cases mixing is influenced by the initial position of a heterogeneity in the flow and is still incomplete after about a dozen tracer overturns, which may corresponds to several Ga. Qualitative differences between the mixing properties of the two described flow types can hardly be observed with the used setup.

References

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