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Evolution of Layered Convection in the Earth's Mantle

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The internal structure of the Earth is made up by a series of layers, though it is unclear how many layers exist and if there are layers invisible to remote sensing techniques. The transition zone is likely to be a boundary layer separating the convective systems in the lower and upper mantle. It seems likely that currently there is some mass exchange across this boundary, rather than the two systems beeing strictly separated.a Double-diffusive convection(d.d.c) is a vital mechanism which can generate layered structure and may thus be an important mmical machinery behind the formation of the transition zone. Double-diffusive convection determines the dynamics of systems whose density is influenced by at least two components with different molecular diffusivities.In the mantle, composition and temperature play the role of those two components. By means of numerical experiments we demonstrate that under mantle relevant conditions d.d.c typically leads to the formation of a transition zone. The calculations encompass two- and three dimensional Cartesian geometries as well as fully 3D spherical domains. We have further included strongly temperature dependent viscosity and find that this leads to even more pronounced layering. In most cases a layered flow pattern emerges, where two layers with a transition zone in between resembles a quasistationary state. Thus, the transition zone can be the result of a self organization process of the convective flow in the mantle. The presence of a phase transition further helps to stabilize the boundary against overturning, even on a time scale on the order of the age of the Earth.