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Layer formation in the Early Earth's Mantle

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The thermal history of the Earth, it's chemical differentiation and also the reaction of the interior with the atmosphere is largely determined by convective processes within the Earth's mantle. A simple physical model, resembling the situation,shortly after core formation, consists of a compositionally stable stratified mantle, as resulting from fractional crystallization of the magma ocean. The early mantle is subject to heating from below by the Earth's core and cooling from the top through the atmosphere. Additionally internal heat sources will serve to power the mantle dynamics. Under such circumstances double diffusive convection will eventually lead to self organized layer formation, even without the preexisting jumps is material properties. We have conducted 2D and 3D numerical experiments in Cartesian and spherical geometry, taking into account mantle realistic values, especially a strong temperature dependent viscosity and a pressure dependent thermal expansivity . The experiments show that in a wide parameter range. distinct convective layers evolve in this scenario. The layering strongly controls the heat loss from the core and decouples the dynamics in the lower mantle from the upper part. With time, individual layers grow on the expense of others and merging of layers does occur. We observe several events of intermittent breakdown of individual layers. Altogether an evolution emerges, characterized by continuous but also spontaneous changes in the mantle structure, ranging from multiple to single layer flow. Such an evolutionary path of mantle convection allows to interpret phenomena ranging from stagnation of slabs at various depth to variations in the chemical signature of mantle upwellings in a new framework.