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Dynamical evolution of layered structures in the early Earth

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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. Layering can not be explained by simple gravitational settling. Double-diffusive convection (d.d.c) is considered as a vital mechanism behind the generation of layered structures. We demonstrate that d.d.c can lead to layer formation on a planetary scale in the diffusive regime where composition stabilizes the system while heat provides the destabilizing force. Choosing initial conditions in which a stable compositional gradient overlies a hot reservoir we mimic the situation of a the early Earth in a phase after core formation. Differently from earlier studies we fixed the temperature rather than the heat flux at the lower boundary, resembling a more realistic condition for the core-mantle boundary. We have carried out extended series of numerical experiments, ranging from 2D calculations in constant viscosity fluids to fully 3D experiments in spherical geometry with strongly temperature dependent viscosity.The buoyancy ratio R and the Lewis number Le are the important dynamical parameters. In all scenarios we could identify a parameter regime where the non-layered initial structure developed into a state consisting of several, mostly two layers .Initially plumes from the bottom boundary homogenize a first layer which subsequently thickens. The bottom layer heats up and then is initiated in the top layer. This creates dynamically (i.e. without jump in the material behavior) a stack of separately convecting layers. The bottom layer is significantly thicker than the top layer. Strongly temperature dependent viscosity leads to a more complex evolution The formation of the bottom layer is followed by the generation of several layers on top. However this layers generally collapse into one layer, again resulting in a two layer system. We employed a numerical technique, allowing for a diffusion free treatment of the compositional field. In each

case a similar evolution has been observed. This indicates that a temporary formation of layered structures in planetary interiors is a typical phenomenon. The presence of phase boundaries may further help to stabilize the boundaries between the layers against overturning.