Convection in a self-gravitating system

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In order to inquire on the role of convection in global tectonics, one has to take into account that any action exerted from the exterior on a self-gravitating system, or on any fraction of it, produces, all together, departures from lateral homogeneity, local isotropy and radial gradient of density(1). As a consequence, mass and/or energy transfer spontaneously takes place tending to reduce the above departures.

The beginning of mass transfer known as 'convection' has been observed in systems consisting of one or more fluids subjected to gravity, when introduction of heat makes laterally not homogeneous their temperature, leading to departure from lateral homogeneity of density(2) and from local lateral isotropy (i. e., local equilibrium hydrostatic pressure). Convection tends to reduce these departures.

Within the bulk of low viscosity fluids, the departure from equilibrium hydrostatic pressure is so slight that the lateral non uniformity of density and the departure from the equilibrium radial density gradient can be considered as the only driving forces responsible for mass transfer. In a horizontal liquid layer, the warmer, less dense fluid moves to overlap the colder, more dense fluid. If the lateral gradient persists in time, the mass transfer shows a cyclic course (formation of Bénard convection cells), with the warmer fluid going upward to the top of the layer, and the colder fluid going downward. As a consequence, temperature at the top free surface loses its uniformity making the surface tension not homogeneous.

If the lack of homogeneity of the surface tension is obtained heating not uniformly the liquid layer from the top, the ensuing departure from local isotropy becomes relevant, so that mass transfer tending to reduce such a departure may prevail: especially in micro-gravity conditions. If the lateral temperature gradient is maintained in time, it becomes cause of convective mass transfer (formation of Marangoni convection cells), with the colder fluid going upward and the warmer fluid going downward.

The outer shell of the 'solid' Earth is more complex than the top surface of a liquid layer, but it seems to behave, as a whole, like a very high viscous fluid floating over less viscous matter. Lateral unevenness of temperature may explain the not homogeneous state of stress of the crust and the consequent spontaneous mass transfer tending to reduce the local departures from equilibrium hydrostatic pressure. Most of the mass transfer consists in the wedging of underlying less viscous matter, tending to reduce local deficiency of lateral pressure, and in the subduction of portion of the overlaying more viscous shell, tending to reduce local excess of lateral pressure. The mass transfer within the outer shell, as shown by its deformation, is subordinate.

The persistency of the mass transfer suggests that the latter is following a cyclic course and, consequently, that the action 'from the exterior' on the Earth crust persists in time.

To know if the state of stress is cause of, or is caused by convention - that is, if the system is open at its top, or at its bottom - we have first to locate the energy source needed to keep in existence the departure from equilibrium.

(1) - See the abstract "Global departure from equilibrium in a self-gravitating system and global tectonics".

(2) - In a vertical liquid layer heated from one or both sides, convection starts as soon as temperature becomes laterally not homogeneous. In a liquid layer heated from below, convection starts when - because of the uneven heating, or because of the unavoidable local fluctuations of temperature and density if the heating is homogeneous in the average – one or more hotter spots whose density is lower than that of the adjoining regions come in existence at the layer bottom.