Global departure from equilibrium in a self-gravitating system and global tectonics.

Giuseppe (Pino) GUZZETTA

Università di Napoli Federico II.

Many dynamical processes take place in our planet Earth because of some departure from the equilibrium state to which it spontaneously tends as a system subjected to its own gravity field. A sound recognition of this equilibrium state is an essential requirement in order to interpret correctly the already available evidence of processes that occurred in the past and/or now in progress, and to focus on the most appropriate investigations to undertake in the future.

Taking into account only the gravitational field, one should expect that, in the absence of 'external' actions, the matter making up the self gravitating system Earth would tend spontaneously to be arranged in a disordered way along every equipotential surface, and in an orderly way in directions normal to these surfaces. The disordered arrangement along the potential surfaces would give rise to lateral statistical homogeneity and isotropy; the radial order would consist in the stacking of less dense over denser matter. It is worth pointing out that the departures from *lateral homogeneity*, from *local isotropy* and from *equilibrium density gradient* are strictly interlaced. In fact, the arising of each one of these three departures necessarily implies that of the other two.

Unfortunately, the current state of the art forces us to deal with the above departures from equilibrium as they were unrelated.

A departure from lateral homogeneity can be, in a way, considered as a departure from thermodynamic equilibrium. After all, the tendency to lateral homogeneity - extendable to the third dimension when dealing with not too wide systems in which the slight difference between "up" and "down" can be disregarded - led to the conception of thermodynamics. Anyhow, since in this theory the gravitational field is considered as external, the spontaneous tendency to lateral homogeneity of composition is limited to mixable phases.

A departure from the equilibrium pressure and density gradients in the gravity field, can be explained, without thermodynamic argumentations, as a departure from hydrostatic equilibrium.

Finally, it goes often unnoticed that a departure from local isotropy along equipotential surfaces - that is, that departure from isotropy a volume element included between two close equipotential surfaces shows being in a non-hydrostatic state of stress and/or having acquired strain anisotropy – is a departure from equilibrium. Notwithstanding, this anisotropy gives rise to spontaneous processes tending to restore isotropy of both state of stress and structure. Thermodynamics and hydrostatics cannot explain such a phenomenon.

The disjointedness of the current way of perceiving and explaining different facets of a single global physical phenomenon, certainly does not help in investigating causes and development of a process such as global geodynamics. To help in reducing the unavoidable groping, comprehensive *thermo-gravitational* equilibrium conditions are here defined, without raising any doubt about the validity of the conventional *thermodynamic* and *hydrostatic* equilibrium conditions, being the tendency to the latter ones, together with the tendency to *isotropy of structure*, expression of the spontaneous tendency to *lateral* disorder and *radial* order, jointly imposed by the existence of the gravity field. To define such a global equilibrium condition, one has just to extend to the whole self-gravitating system Earth what may be easily observed in its atmosphere: namely, *the spontaneous tendency to homogenisation of entropy per unit mass*.

All the thermodynamics principles should be considered valid, as they have been stated, *only* in systems included between any two close equipotential surfaces of the gravity field. Anyhow, in a whole system subjected to its own gravity field, or in any isolated large fraction of it, an equilibrium thermal gradient must be associated to the equilibrium pressure and density gradients.

More than once, the existence of an equilibrium thermal gradient has been hypothesized by someone to justify the thermal gradient observed in the atmosphere and then discarded by some other one as incompatible with the validity of the second law of thermodynamics, or has been hypothesized by someone else to invalidate the second law and then discarded by the opponent on duty who gave as granted the validity of this law. However, relativistic thermodynamics seems to enforce in equilibrium an inhomogeneous temperature distribution in the atmosphere.

Unanimity may be reached just by considering that at least part of any increase (or decrease) of gravitational potential energy should correspond to a decrease (or increase) of heat. Since, considering the gravitational potential energy as part of the internal energy, one has to recognize that a self-gravitating system spontaneously tends to lateral homogeneity and radial inhomogeneity of temperature, the second law should be restated for a whole self-gravitating system in the following way: heat does not pass from one body to another if such a passage would destroy a state of equilibrium.

The assumption that heat supply at depth should be responsible for convection in the lower mantle is basically supported by the observed existence of the geothermal gradient that, as a whole, is currently considered expression of a departure from equilibrium. Besides looking for further observational and experimental verification of the tendency to *thermo-gravitational* equilibrium, it would be worth trying to check if all the already available evidence can be considered in agreement with the above suggested working hypothesis. Such a trial could lead to a new way of conceiving and evaluating what is currently considered evidence of heat flow in the mantle and the crust, perhaps allowing a distinction between the departure from this gradient responsible for the overall mass transfer we call global tectonics, and the local ones, responsible for heat flows stemming out from dissipative processes and giving rise to shallow secondary mass transfer. Some of the local departures from thermal equilibrium, resulting from the ignored or undervaluated heat release during the spontaneous isotropization of previously strained rock masses, should be taken into account besides the ones resulting from heat released during deformation.

P. S. - A book on this subject has been published in Italian (www.geocities.com/pino_guzzetta). For a free copy of the whole book in English please write to guzzetta@unina.it.