A new form of the equation system for geodyamics with clear and solid physical basis

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As the equation system for describing dynamical phenomena of the solid interior of the Earth such as mantle convection, plate tectonics and their interaction and so on, the equation system for Maxwellian viscoelastic media has been adopted so far. However, the idea that the interior of the earth behaves as a viscous fluid on long time-scales (e. g. Turcotte and Schubert, 2002) cannot be accepted from the simplest physical viewpoint that rocks are elastic solids in the usual sense of physics. Their dynamics must obey physical law of elastic solids regardless of time-scales. The origin of regarding long time-scale evolution of the solid earth as that of a viscous fluid might be similarity between creep of solids (including rocks) and motion of viscous fluids (e. g. McKenzie, 1967). However, creeping occurs as a result of transformation of temporal elastic strain into plastic permanent strain, often referred to as (elastic) stress relaxation. This is a physical process other than dynamical force balance, and hence it must be included in the basic equation system for geodynamics separately from the equation of motion. In the equation of motion, elastic force balances with other forces on long time-scales, where no viscous force is working. Starting from this system of two equations resultant mathematical expression becomes very similar to the equation of motion of viscous fluids if the rate of plastic displacement is identified with fluid velocity. Even with this similarity in recent numerical simulation studies treating mantle convection and plate motion together, in which fundamental unknown variable is fluid velocity, it is pointed out that behaviors of solid plates are not well simulated. In the proposed new form of basic equations the dynamical balance (equation of motion) is that of elastic solid so that this difficulty must be avoided. Further, in the new form dynamics equation is the one for elastic solid so that it can be extended to include brittle feature of the solid to generate fractures, i. e., earthquake and faulting. Thus new form of the basic equation system can be common basis for such important challenges in geodynamics.

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