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プレート境界を通したプレート回転運動のダイナミクス
Dynamics of plate spin motion through plate boundary

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Compared with other planets, the Earth has a variety of special features. One of them is plate tectonics. Because of the feature, the Earth's surface has unique motions such as strike-slip motion along plate boundary and spin motion of a plate. Regarding strike-slip motions, they lead to vorticity along the plate boundary and we can consider the vorticity as an infinitesimal spin motion. Therefore, both strike-slip motion and spin motion of a plate are spin motions and consequently we would state that it is spin motions that characterize plate tectonics and the Earth. However, the dynamics of spin motion is not well understood, thought the plate spin motion must include vital information about plate tectonics, especially the dynamics of plate boundary which is the most intricate problems in this field. Hence, we here focus on the dynamics of plate spin motion.

To begin with, we analyzed the basic equation of mantle convection since plate tectonics is a part of mantle convection as the thermal boundary layer and we will grasp the dynamics of plate tectonics from that of mantle convection. The analysis shows that the effect associated with the horizontal viscosity variation of the surface is indispensable to generate vorticity or plate spin motion. As a parameter of the horizontal viscosity variation, we make use of individual plate size since a plate size expresses the distance between hard plate center and soft plate boundary and is therefore one of simple parameters to consider the influence of the horizontal viscosity variation. Dividing observed Euler poles into two components: spin Euler pole associated with spin motion of a plate and straight Euler pole associated with straight motion of a plate, we revealed that the potential energy generated by subduction excites the plate motion, particularly the straight motion, in a large scale motion and the straight motion transmits into the spin motion through the plate boundary, especially in a small scale motion, mainly less than 1000 km of the radius of plate. In addition to the individual plate analysis for plate spin motion, the global plate motion analysis called spherical harmonic expansion also demonstrates the transmission from the straight motions into the spin motions in a small scale motion.

These results suggest that while small plates have high spin motions since they receive the force to spin through the plate boundary without large deformation, i.e., low strain rate, large plates do not have high spin motion since the force to spin does not well transmit because of the large deformation, i.e., high strain rate, along the plate boundary which we call a "strike-slip" boundary. This difference of force transmission, or strain rate, along plate boundary in plate size might be associated with the difference of the stress along the plate boundary; for example, we need larger stress along plate boundary in order to spin larger plates. In other words, this difference might be attributed to the rheology of plate tectonics, especially along plate boundary. Estimating the stress to spin, we will obtain the rheology of plate boundary from observation, that is, plate motion, which advances the theory of plate tectonics substantially.

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