Development of a three-dimensional mantle convection model with tectonic plates induced by stress-history dependent rheology

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In today’s Earth, solid plate interiors and ruptured plate boundaries coexist at a stress level typical for the Earth’s interior. A stress much higher than this level is necessary to rupture an intact plate and to introduce a new plate boundary. Once a plate boundary develops, however, it does not immediately disappear, even if the stress is reduced to the original level: the rheological state of a plate depends on its stress history. We reproduced tectonic plates in our three-dimensional mantle convection models calculated with ACuTEMAN code (Kameyama 2005; Kameyama et al. 2005) by introducing this stress-history dependent rheology. We discriminated the plate boundaries and plate interiors by introducing a damage parameter that depends on the stress-history that the material has experienced: this parameter takes a value less than one in intact plate interiors, but takes a large value at plate boundaries. One of the difficulties we encountered in calculating this model is the numerical instability that occurs when a fine structure with a large viscosity contrast develops along plate boundaries: The viscosity contrast becomes as large as three orders of magnitude. To avoid this difficulty, we introduced a diffusion of the damage parameter. The magnitude of the diffusion is adjusted so that it does not affect the global configuration of tectonic plates but does smear out the fine structures at plate boundaries. In the poster, we will present some examples of tectonic plates that we calculated.

Keywords: mantle convection, numerical simulations, tectonic plates, stress-history dependent rheology

