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Dynamical models for initiation of subduction in the mantle convection: driving force and temperature in the subdcution zone

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We have developed self-consistent dynamical models of the plate-mantle convection system to understand dynamics of initiation of the subduction. We utilize rheology depending on the hysteresis of the stress to realize the subduction-like descending flow of a cold thermal boundary layer with high viscosity (Honda et al., 2000). No external forces are applied to the surface boundary and the plate in the model. We here use realistic rheology including Arrhenius-type temperature and pressure dependence and maximum yield strength whose values are in the range of 200 to 600 MPa (400 to 1200 MPa in a deferential stress) as large as those reported by the experimental studies for the rheology of the lithosphere.

Our results show that the subducted slab is formed when the strength of a fault zone at the plate boundary is small enough. This does not strongly depends on the maximum strength of the lithosphere, namely, the subduction successfully occurs even at the highest value in the model (600 MPa). We also analyze forces working on the plate and the slab. At the initial condition, motion of the plate begins with compressive force induced by the shape of the plate (ridge push force) and plume (mantle-drag force). A negative buoyancy by the slab balanced with resistance by the overriding plate until the slab penetrates into the depth of 150 to 200 kilometers. This implies that the force continuously pushing plate such as mantle-drag force to initiate the subduction until the slab reaches the depth at which the slab-pull force overcomes the resistance.