Lowermost mantle evolution coupled with the plate subduction

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Subducted plates is expected to be one of the significant factor deciding structures and the evolution of the Earth's lower mantle. Seismic analyses indicate that spatial distribution of the large low shear velocity provinces on the lowermost mantle have prominent features, for example, correlation with hot spot locations [1]. We investigate that influence of the lower mantle properties on mechanical interaction between the subducted plate and the compositionally dense layer, using a mantle convection model in which plate-like motion is realized without any forces imposed on the surface plate [2]. Our 2-D Cartesian numerical model has chemically distinct dense material layer with the density contrast of +77.3 kg m^{-3} on the core mantle boundary (CMB). We also incorporate phase changes of hydrous minerals [3] and hydration effects on the density and the viscosity into the model [4]. In this study, we focus on the following parameters; depth dependence of the thermal expansivity, the depth profile of the background mantle viscosity and the yield strength of the slab.

We found that two types of systems of rising plumes. When the thermal expansivity is constant in the whole model space, the dense segments deform strongly and rise off the CMB as the plume so that the subducted slab plunges into the dense piles. In this case, the dense segments become unstable. When the thermal expansivity decreases with the depth, plumes are generated on the top of the dense piles. In this case, the plate velocity slows down and mantle convection becomes gentler, even when the lower mantle viscosity is small. This effect leads to the convection layered at the boundary between the regular mantle and the dense segments, such that the active convection is induced in the dense layer while the slow convection is generated in the regular mantle layer. Steep temperature increase overlaps at the chemical boundary above the dense materials. These plumes entrain only small amount of the dense materials and, consequently, the dense piles are stablily sustained for a long term.

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