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Ascending flows in the Big Mantle Wedge (BMW) beneath northeast Asia induced by retreat and stagnation of subducted slab

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We conducted numerical experiments of mantle convection in order to study the mechanism for the generation of ascending flows in the "Big Mantle Wedge" (BMW), which has been recently proposed by Zhao and coworkers in order to relate the stagnant Pacific slab with the intraplate volcanism in Northeast Asia. In this study, we consider a time-dependent convection of fluid under the extended Boussinesq approximation in a model of a two-dimensional rectangular box of 2000 km height and 6600 km width. We have included both the exothermic olivine to spinel and the endothermic post-spinel phase transitions at around 410 and 660 km depths from the top surface, respectively. The viscosity of mantle material is assumed to be exponentially dependent on temperature and pressure (or depth). We also take into account the effects of the sudden increase in viscosity at the 660 km depth. The plate subduction is modeled by a downward flow of cold and viscous fluid along with a pre-assigned conduit which mimics the path of the descending slab from the top surface to the mantle transition zone (MTZ). In addition, we take into account the effect of trench retreat, by imposing a oceanward migration of the conduit with respect to the deep mantle.

Our calculations demonstrated that the retreating motion of trench is of the primary importance on the slab stagnation: For a sufficiently fast trench retreat, the subducting slab tends to stagnate near the 660 km depth. In addition, the horizontal extent of the stagnant slab, once it forms in the MTZ, increases with time almost in proportion to the trench retreat. This means that the BMW is extended oceanward in response to the retreating motion of trench and slab and, in other words, the toe of stagnant slab is significantly anchored in the mantle. We also found that the oceanward extension of BMW has a strong control on the flows in the region. In particular, there occurs a local but strong circulation near the oceanward end of the BMW just above the stagnant slab. This local circulation is driven by the subducting and retreating motion of slab, and induces an ascending flow which pulls up cold fluids near the stagnant slab. Our findings suggest that ascending flows in the BMW can be mechanically-triggered most easily near the oceanward end (or a hinge) of the stagnant slab, which is in good accordance with the occurrence of several Cenozoic volcanoes in East Asia above the stagnant Pacific slab.

Keywords: stagnant slab, mantle convection, trench retreat, Northeast Asia, volcanism, Big Mantle Wedge