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Are LLSVPs formed in the Earth's lowermost mantle by the subduction of oceanic crusts?

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We conducted a series of numerical experiments of thermo-chemical mantle convection where a subduction is preferentially induced at a continental margin, in order to verify a hypothesis that the Large Low-Shear Velocity Provinces (LLSVPs) in the Earth's lowermost mantle are formed by subduction of oceanic crust. In this study, we adopted a model of two-dimensional rectangular box of 2900km height and aspect ratio 6 with reflective boundary condition in the horizontal direction. We placed an immobile lid as a model of surface supercontinent which covers a third of the top surface. We also put a thin layer of chemically dense materials as a model of oceanic crust, which may sink into the deep mantle along with cold descending flows from the top surface.

Our calculations showed that the subducted oceanic crusts are preferentially provided under the continent when the subduction at the margin of continent is stable. However, stable subduction caused strong convection and significantly stirred the mantle under the continent. Therefore, subducted oceanic crusts were distributed almost uniformly under the continent without accumulating on the CMB. On the other hand, the cases with unstable subduction at the margin of continent showed a long-wavelength mantle convection structure which has an ascending plume along the side wall under the continent and a descending plume at the opposite side wall. The large-scale flow gathered subducted oceanic crusts under the continent and formed large piles on the CMB.

Our results suggest that the LLSVPs are hardly formed in the presence of stable plate tectonics like the current one where a stable plate motion including subduction stirs the mantle very effectively. In other words, the formation of large thermochemical piles which are equivalent to the LLSVPs should have been completed before the plate tectonics is well established, assuming that subducted oceanic crusts are the origin of LLSVPs.

Keywords: mantle convection, numerical simulation, LLSVP, plate subduction