Conjecture with Water and Slab Dynamics Simulation

Fumiko Tajima* and Masaki Yoshida

Depart. Earth and Envr. Sci., Ludwig-Maximilians-Universität (LMU) Munich (visitor),
IFREE, JAMSTEC, Yokosuka, Kanagawa 237-0061, Japan, * tajimafumiko741@gmail.com

Abstract

Seismic observations suggest structural variations near the base of the mantle transition zone (MTZ) where subducted slabs flatten to form stagnant slabs or sink further into the lower mantle. The different slab behaviors were also accompanied by variation of the “660 km” discontinuity depths that may correspond to the effects of water on the phase transformation pressures (depths) and viscosity reduction of major geochemical properties suggested for garnet and olivine in recent high pressure experiments [Ohtani & Litavsky, 2008; Kalyana & Karato, 2008]. Interpretations given for observed seismic anomalies are rather equivocal in terms of temperature, geochemical compositions, water content, and accordingly variations of rheological properties.

A systematic series of numerical experiments has been conducted to examine the effects of viscosity reduction and “660 km” discontinuity (phase transformation) depths as well as the viscosity contrasts between the subducted oceanic crust and mantle, and the depth variation under wet conditions [Yoshida et al., 2012]. The viscosity reduction of crustal materials in the wet MTZ leads to separation and transient stagnation of crustal materials. A significant volume of subducted crustal materials (i.e., more than 50 %) is transiently trapped in the MTZ. However, the once trapped crustal materials sink into the lower mantle within 20 My, a relatable short time as compared with the whole mantle convection cycle (up to ~200 My).

The numerical simulations based on seismic and experimental observations suggest slab materials recycle in the whole mantle.

< Governing equations & parameters>

< 3D Numerical Simulation >

< Examined model parameters >

Discussion

We have shown that the subducted crustal materials are once trapped along with stagnant slabs in the MTZ due to viscosity reduction under hydrous condition, and then sink further into the lower mantle within a relatively short time (less than ~20 My), which is consistent with seismic observations [e.g., Tajima and Grand, 1998] and much shorter than the whole mantle convection cycle (up to ~200 My).

The results suggest that the megathrust formation in the MTZ postulated by Ringwood and Inunde [1988] or an enriched MTZ suggested using a 2D numerical experiment by van Keken et al. [1996], is unlike to take place. The structure (rheological properties and density distributions) associated with stagnant slabs may be formed under control of subduction direction, and the details may not be necessarily manifested using tomography modeling.

Seismic sampling & subduction geometry

Variation of stagnant slab geometry

< Postulated model >

< Seismic observations >

< 3D Numerical Simulation >

< Governing equations & parameters >

< Examined model parameters >

Discussion

We have shown that the subducted crustal materials are once trapped along with stagnant slabs in the MTZ due to viscosity reduction under hydrous condition, and then sink further into the lower mantle within a relatively short time (less than ~20 My), which is consistent with seismic observations [e.g., Tajima and Grand, 1998] and much shorter than the whole mantle convection cycle (up to ~200 My).

The results suggest that the megathrust formation in the MTZ postulated by Ringwood and Inunde [1988] or an enriched MTZ suggested using a 2D numerical experiment by van Keken et al. [1996], is unlike to take place. The structure (rheological properties and density distributions) associated with stagnant slabs may be formed under control of subduction direction, and the details may not be necessarily manifested using tomography modeling.

Seismic sampling & subduction geometry

Variation of stagnant slab geometry