# Whole mantle dynamical simulation for aqueous fluid transportation and Pb–Sr–Nd isotopic evolution

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## Introduction

Subduction zone fluids are regarded as an essential factor in global isotopic heterogeneities of mantle rocks (e.g., Tatsumi, 2005; Iwamori & Nakamura, 2015). However, it is still controversial how the heterogeneities have been created, distributed, and developed through Earth's history (e.g., layered vs. hemispherical; long-term accumulation vs. effective propagation). We aim at constructing a numerical model that incorporates consistently both geochemistry and physics of fluid-solid two-phase mantle convection.

## Methods

On the basis of Nakao et al. (2016, EPSL), we newly construct a 2-D fluid dynamical model with the direct method plus marker-in-cell techniques, including:
(1) Spontaneous plate subduction and whole mantle convection;
(2) Water transportation via solid and aqueous fluid phases;
(3) Water-content-dependent viscosity and density;
(4) Advection, fractionation, and radioactive decay of U, Th, Pb, Rb, Sr, Sm, and Nd in both solid and aqueous fluid phases. Partition coefficients are based on Kessel et al. (2005) for the upper mantle, and are parameterized for the lower mantle.

## Results and Discussion

***Mantle wedge process:*** The simulation results reproduce dehydration of MORB and the overlying serpentinite, as well as the corresponding extraction of hydrophiles in mantle wedge. The aqueous fluids bearing the incompatible elements ascend towards the base of the overlying continental plate. However, the spatial distribution of chemical heterogeneity with variable U/Pb generated in this process is limited to a region around the subducting slabs. They sink into and pile up at the bottom of the mantle due to their large density and viscosity. This may account for an origin of the hidden reservoir with an extremely high Pb isotopic ratio (e.g., Tatsumi, 2005).
***Lower mantle process:*** On the other hand, the simulation shows that dehydration of hydrous ringwoodite just below the 660-km discontinuity (e.g., Schmandt et al., 2014) causes efficient propagation of the hydrophilic heterogeneity. The boundary works as a filter of water and hydrophiles carried by penetrating oceanic slabs, creating hydrous ringwoodite piles enriched in the hydrophiles (i.e., small U/Pb) along the bottom of the transition zone. By contrast, depleted residues (i.e., large U/Pb) are continuously generated at 660 km, sinking into the lower mantle. Since the chemical heterogeneity around the 660 is located in a hotter, less viscous region, it can be transported widely within a short period of time. The hydrous ringwoodite piles over the 660 occasionally generate hydrophile-rich wet plumes due to their small density. We consider the wet plumes from the 660 during continent gathering as a possible origin of the hemispherical isotopic heterogeneity (Iwamori & Nakamura, 2015) because continental collision (i.e., trench advance) and slab penetration at the 660 tend to occur simultaneously.

Keywords: mantle convection, water transportation, chemical evolution, dehydration of ringwoodite, wet plume, isotopic ratio

 