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The role of harzburgite layers in the morphology of subducting plates and the behavior of oceanic crustal layers

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Previous numerical studies of mantle convection focusing on subduction dynamics have indicated that the viscosity contrast between the subducting plate and the surrounding mantle have a primary effect on the behavior of subducting plates. The seismically observed plate stagnation at the base of the mantle transition zone (MTZ) under the Western Pacific and Eastern Eurasia is considered to mainly result from a viscosity increase at the ringwoodite to perovskite + magnesiowüstite (Rw→Pv+Mw) phase decomposition boundary, i.e. the boundary between the upper and lower mantle.

The harzburgite layer, which is sandwiched between basaltic crust and depleted peridotite (lherzolite) layers, is a key component of highly viscous, cold oceanic plates. However, the possible sensitivity of the effective viscosity of harzburgite layers in the morphology of subducting plates that are flattened in the MTZ and/or penetrated in the lower mantle has not been examined systematically in previous three-dimensional (3D) numerical modeling studies that consider the viscosity increase at the boundary between the upper and lower mantle.

In this study, in order to investigate the role of harzburgite layers in the morphology of subducting plates and the behavior of oceanic crustal layers, I performed a series of numerical simulations of mantle convection with semi-dynamic plate subduction in 3D regional spherical-shell geometry.

The results show that a buckled crustal layer is observed under the “heel” of the stagnant slab that begins to penetrate into the lower mantle, regardless of the magnitude of the viscosity contrast between the harzburgite layer and the underlying mantle, when the factor of viscosity increase at the boundary of the upper and lower mantle is larger than 60–100. As the viscosity contrast between the harzburgite layer and the underlying mantle increases, the curvature of buckling is larger. When the viscosity increase at the boundary of the upper and lower mantle and the viscosity contrast between the harzburgite layer and the underlying mantle are larger, the volumes of crustal and harzburgite materials trapped in the mantle transition zone (MTZ) are also larger, although almost all of the materials penetrate into the lower mantle. These materials are trapped in the MTZ for over tens of millions of years.

The bending of crustal layers numerically observed in the present study is consistent with seismological evidence that there is a piece of subducted oceanic crust in the uppermost lower mantle beneath the subducting slab under the Mariana trench [Niu et al., 2003, JGR].

The results of the present study suggest that when the viscosity increase at the boundary of the upper and lower mantle is larger than 60–100, a seismically observed stagnant slab is reproduced. This result is consistent with the previous independent geodynamic studies. For instance, a 2D geodynamic model with lateral viscosity variations suggested that it would need to be substantially greater than 30, say, around 100, to explain the positive geoid anomaly in the subduction zones where the subducting slab reaches the boundary between the upper and lower mantle such as that of the western Pacific [Tosi et al., 2009, GJI].

References:
[1] Tajima, F. Yoshida, M. and Ohtani, E., Conjecture with water and rheological control for subducting slab in the mantle transition zone, Geoscience Frontiers, doi:10.1016/j.gsf.2013.12.005, 2014.
[2] Yoshida, M. The role of harzburgite layers in the morphology of subducting plates and the behavior of oceanic crustal layers, Geophys. Res. Lett., 40(20), 5387-5392, doi:10.1002/2013GL057578, 2013.
[3] Yoshida, M. and Tajima, F., On the possibility of a folded crustal layer stored in the hydrous mantle transition zone, Phys. Earth Planet. Inter., 219, 34-48, doi:10.1016/j.pepi.2013.03.004, 2013.