# Effects of transformation kinetics on the density and strength of the descending oceanic plate into the deep mantle

# Tomoaki Kubo[1], Eiji Ohtani[2], Tomofumi Hosoya[3], Akira Shimojuku[4]

[1] Tohoku Univ, [2] Institute of Mineralogy, Petrology, and Economic Geology, Tohoku University, [3] Inst. Min. Petro. and Eco., Tohoku Univ., [4] Faculty of Science,Tohoku Univ.

As the oceanic plate descends into the deep mantle, the major constituent minerals of olivine, pyroxene, and garnet cause high-pressure transformations. It has been suggested that these transformations is kinetically inhibited due to low temperatures in the plate and metastable low-pressure phases exist beyond the equilibrium boundary. Because the density increase ~5-10% caused by these transformations is much larger than the thermal density difference between the plate and the surrounding mantle, kinetics possibly affects dynamics of the subducting slab. We examined kinetics of the olivine-spinel transformation, high-pressure transformations in enstatite and diopside, the post-spinel transformation, and the post-garnet transformation by in-situ X-ray observations at 13-32 GPa and 1000-2000K. Taking kinetics of these transformations into account, we discuss the metastable mineralogy, density and strength in the peridotite layer of the slab.

Pyrolite model was used as mineral proportions in the peridotite layer of the slab. We assume that reactions between garnet and pyroxene can not occur due to the slow chemical diffusion at low temperatures of the cold slab. Therefore, it is expected that near iso-chemical transformations occur in olivine, pyroxene, and garnet. Transformed fractions were calculated as a function of depth based on the experimentally determined growth kinetics in theses transformations. Olivine and pyroxenes can survive metastably to around 550-600 km depths in the cold slab, however the post-spinel transformation can complete near the equilibrium boundary. On the other hand, metastable garnet exists more than 1000 km depths due to the slow growth rates. The density of each mineral was calculated using high-temperature Birch- Murnaghan equation of state, and the viscosity of the slab was estimated taking into accounts the grain-size reduction due to the olivine transformations.

The cold slab (T=923K at 660 km depth) becomes buoyant both in the transition zone and at the top of the lower mantle because of the presence of metastable olivine in the transition zone, and negative slope of the post-spinel transformation boundary and the presence of the metastable garnet in the lower mantle. The strength of the slab is largely reduced around 470 km depth due to the grain-size reduction by the olivine-spinel transformation. The warmer slab (T=1123-1323K at 660 km depth) is denser than the surrounding mantle in the transition zone, however becomes buoyant in the lower mantle due to the negative slope of the post-spinel transformation boundary and the presence of the metastable garnet. The warmer slab does not weaken in the transition zone but at the top of the lower mantle due to the grain-size reduction by the post-spinel transformation.

Although we have to consider effects of latent heat production on transformation kinetics, these preliminary results suggest that metastable phase transformations would have an important role on the dynamics of the slab at around the 660 km discontinuity. Our results are almost consistent with recent seismic tomography that reveals the subducting slabs become weak and buoyant in the transition zone and at the top of the lower mantle.