Cool lower mantle transition zone inferred from seismic anisotropy of deformed ringwoodite

*Takaaki Kawazoe[1,2], Florian Heidelbach[2], Nobuyoshi Miyajima[2], Takayuki Ishii[2]

1. Hiroshima Univ., 2. Univ. Bayreuth

Seismic anisotropy is a powerful tool for inferring dynamics in the Earth's interior and recently detected in the lower part (520-660 km depth) of the mantle transition zone (MTZ). The most plausible explanation for seismic anisotropy in the lower MTZ is crystallographic preferred orientation (CPO) of ringwoodite because ringwoodite is dominant in the region (~60 vol%) and has single-crystal anisotropy up to ~10% while the second dominant mineral (majoritic garnet, ~40 vol%) is elastically isotropic. Here we show that CPO of ringwoodite cannot account for seismic anisotropy in the lower MTZ by analyzing ringwoodite samples deformed at 17-18 GPa and 1300-1500 K with a deformation-DIA apparatus and by simulating ringwoodite deformation by viscoplastic self-consistent modeling. The deformed ringwoodite samples showed clear CPO patterns primarily attributed to dislocation glide with the 1/2<110>{111} slip system; however, calculated seismic anisotropy of the model mantle rock was less than 0.4%. To explain seismic anisotropy in the lower MTZ, akimotoite is necessary to exist in the lower MTZ, whose CPO can produce seismic anisotropy in this region. In this hypothesis, temperature in the lower MTZ should be lower than its present estimate by more than 200 K because akimotoite is stable at relatively low temperature.

Keywords: mantle transition zone, seismic anisotropy, ringwoodite, crystallographic preferred orientation, high pressure, deformation

