

Kinetics of the two-stage post-spinel transformation under subduction zone conditions: Implications for mantle flow across the 660-km discontinuity

*Tomoaki Kubo¹, Hiroshi Kojitani², Satoshi Kaneshima¹, Yuji Higo³, Yoshinori Tange³

1. Kyushu Univ., 2. Gakushuin Univ., 3. JASRI

Recent first-principles studies and thermodynamic calculations have revealed the presence of the stability field of akimotoite (Aki) and periclase (Pc) in Mg_2SiO_4 at lower than $\sim 1100^\circ\text{C}$, suggesting that the post-spinel transformation occurs by a two-stage process in cold subducting slabs, that is ringwoodite (Rw) \Rightarrow Aki+Pc \Rightarrow bridgmanite (Brm)+Pc. However, the direct experiment to determine these phase boundaries have been kinetically difficult. Here we report results of in-situ X-ray and microstructural observations on the kinetics of the two-stage reaction “metastably” occurred at the Brm+Pc field of 24.5-27 GPa and 1050-1300 $^\circ\text{C}$ in Mg_2SiO_4 . The reaction first occurs by nucleation and growth of metastable Aki+Pc eutectoid colonies on the parental Rw polycrystal, followed by overprint of bigger Brm+Pc eutectoid colonies on the metastable colonies. The faster appearance of the Aki+Pc assemblage may be due to the coherent nucleation. We deduced nucleation and growth kinetics of the eutectoid colonies in each reaction from time-resolved XRD data, which was used to evaluate kinetic boundaries under subduction zone conditions considering thermodynamic driving force. We found that the two-stage reaction is kinetically possible in cold slabs penetrating into the lower mantle, in which the pressure interval of the Aki+Pc field decreases from ~ 1.2 GPa at 700 $^\circ\text{C}$ to zero at $\sim 1100^\circ\text{C}$. This potentially affects the slab dynamics across the upper and lower mantle boundary. We will discuss on density and velocity jumps of cold slabs expected through the two-stage post-spinel transformation and its seismological detection by using the S-to-P wave conversion at the discontinuity. Its effects on the slab rheology will also be investigated considering the grain-size evolution during the double eutectoid reactions.