# Report for the Joint Use/Research of the Institute for Planetary Materials, Okayama University for FY2023

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**Category:** ☑International Joint Research ☐General Joint Research ☐Joint Use of Facility ☐Workshop

**Name of the research project:** The relative strength of MORB and pyrolite at the upper/lower mantle boundary

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**Research report:**

Subducted oceanic lithosphere is composed of two chemically distinct layers, namely mid-ocean-ridge basalt (MORB) and depleted peridotite layers (harzburgite, Hbg). The fate of MORB and Hbg layer has important implications for: (1) complex slab behavior and mantle convection around 660-1000 km depth; (2) the production of seismic scatters in the lower mantle; (3) the source of enriched OIB at the core-mantle boundary and the base of the transition zone and (4) the composition and origin of enriched components in OIB magmas. The strength (viscosity) contrast of the MORB layer with the underlying Hbg slab core and surrounding mantle plays an important role in controlling the behavior of MORB layer, e.g., a moderately stronger (0-2 orders) MORB layer is favored for the delamination of MORB atop 660 km (Karato, PEPI 99, 103-111, 1997). However, little is known about the viscosity of deep subducted slab and its components. Therefore, we propose to measure the relative strength of MORB and Hbg under the range of pressure and temperature conditions of the subducting slab across the mantle transition zone to ~800 km depth.

During FY2022FH IPM joint use, we started with conducting deformation experiments on MORB and Hbg two layered samples, i.e., pre-synthesized ringwoodite (Rw)/post-spinel (PS) sample against MORB composition, with D111 apparatus. We found that the Rw and MORB shows very small strain contrast, i.e., smaller than a factor of two, which indicates a comparable viscosity of Rw and MORB. On the other side, we found a large strain contrast of one order of magnitude between eutectoid PS (PS just after the phase transition below 660-km which shows eutectoid texture of ferropericlase (Fp) and bridgmanite (Br) with grain size of ~200 nm) and MORB sample. The big viscosity contrast at 660-km may facilitate detachment of MORB layer and the slab. To further understand the mechanism of weakening of eutectoid PS, we conducted uni-axial compressional deformation experiments on eutectoid and equigranular PS during FY2023 IPM joint use.

Our results show that fine-grained eutectoid and equigranular PS (< 1 μm) with similar grain size shows similar strength up to uni-axial strain of 0.35, which indicates that the small grain size of PS rather than the eutectoid texture plays the key role for the weakening of PS deformed in diffusion creep. The weak to absence of lattice preferred orientation of the deformed PS samples further indicates that the deformation mechanism is not dislocation creep dominated. The texture observation found the grain coalescence resulted in a shape preferred orientation of Br and Fp grains, which favors an important role of grain boundary rotation during deformation. As Fp is much weaker than Br (Yamazaki and Karato, 2001), a softening of PS might occur if Fp is interconnected. However, we didn't yet observe the interconnection due to the limited strain in uni-axial compression experiments.

The results of these two joint use visits indicate that highly likely that MORB and Hbg layer have comparable strength through transition zone to lower mantle except extreme softening of PS at the depth just below PS phase transition, which is ~660 km. The weakening is likely due to the grain size reduction of ringwoodite decomposition to PS, which is likely deformed in diffusion creep due to the fine grain size. More experiments are needed to further study the texture and strength evolution of PS during the deformation in diffusion creep with grain boundary sliding. We will propose the next term joint use with IPM on a simple shear deformation with large strain on fine grained PS.