Report for the Joint Use/Research of the Institute for Planetary Materials, Okayama University for FY2024

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Name of the research project: Shear deformation of fine-grained post-spinel and its texture evolution to large strains

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Research report:

During FY2024, two visits to IPM and two projects were conducted respectively. They will be introduced separately as bellowing.

Shear deformation of fine-grained post-spinel and its texture evolution to large strains. Subducting oceanic lithosphere shows a complex range of behaviours around the 660-km discontinuity, which origins from the phase transition of ringwoodite to the post-spinel (PS) composite. Our previous work found that a large strain contrast of one order of magnitude between fine-grained 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). The resulting viscosity contrast between the subducting harzburgite layer and underlying MORB layer at 660-km may facilitate detachment of MORB layer and the slab delamination. 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. To further understand the mechanism of weakening of eutectoid PS, we conducted in-situ deformation experiment at SPring-8 in FY2024. The sample synthesis and experiment preparation were done at IPM under the frame of Joint Use. We succeeded in four deformation experiments with different temperature and strain rate. The stress data are be analyzed. Once successfully analyzed, a fitting of stress-strain rate-temperature will give the flow law of fine grain PS sample. A comparison of the flow law and the deformation mechanism map built in Tsujino et al. (2022) will help us discuss on the deformation mechanism of Br in PS in this study.

Deformation experiments on Al- and H_2O- bearing stishovite. The fate of subducted oceanic crust is significant in generating mantle heterogeneities with critical insights into mantle material circulation. Along with density, viscosity also plays an important role in controlling the behavior of oceanic crust during subduction. Previously, garnet/bridgmanite was considered to dominate the bulk viscosity of oceanic crust as it's volumetrically more abundant and rheologically weaker than the second dominant mineral, stishovite. However, aluminous stishovite was recently reported having the potential to host a considerable amount of water. If water significantly reduce the viscosity of stishovite, the weak stishovite may dominate and reduce the bulk viscosity of subducted oceanic crust. However, experimental constraints on the viscosity of hydrous stishovite are absent up to date. Therefore, we propose to conduct deformation experiments on Al- and H_2O- bearing stishovite at high pressure and high temperature with the D-111 apparatus installed at BL04B1.

During this visit, synthesis of stishovite and preparation of deformation experiments were done at IPM under the frame of Joint Use. Due to the time limit, deformation experiments on pure SiO_2 stishovite were conducted this time. 5 experiments were successfully deformed and analyzed. The current experimental design of 8/3 cell assembly is proved to be very stable. No blow out occurred and no anvil broken during this beamtime. Among them, three deformation experiments were conducted at 22 GPa and two at 15 GPa and temperatures from 1525 K to 2073 K at different strain rate. A further analysis and fitting of stress-strain rate will give the flow law of stishovite sample and the pressure effect on the strength. For one experiment, SiO_2 stishovite and Al-bearing stishovite were deformed simultaneously to check the Al effect on the strength of stishovite. The preliminary results show that Al and H may induce a change of deformation mechanism in stishovite. Further beamtime will focus on the Al and H effect on the rheology of stishovite, including viscosity and deformation mechanism. A challenge on this future work will be the keep of water in the sample. Test of capsule and experimental temperature condition will be required prior to the beamtime. We will propose the next term joint use with IPM on deformation on Al- and H2O- bearing stishovite.