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Rheology of the subducted slab in the lower mantle inferred from the connectivity of ferro-periclase in the post-spinel

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The physical and chemical properties in the earth's lower mantle depend critically on those of the composite aggregate composed of (Mg,Fe)SiO3 perovskite and ferro-periclase (e.g., Ringwood, 1 991). In the composite materials, their textures (spatial distribution of each phase, grain-size, lattice preferred orientation) significantly control many physical properties such as elasticity, viscosity and electrical conductivity.
Knowledge of the mantle rheology is important to understand the dynamics of the earth's interior and therefore rheological properties of dominant constituting materials have been investigated (e. g., Kohlstedt et al., 1976; Yamazaki et al., 2000), and the rheology of the mantle is commonly simulated by rheological properties of the dominant constituting minerals. For example, rheology of upper mantle is considered to be characterized by that of olivine (Karato and Wu, 1993). However, this approach does not work for the rheology of the lower mantle because minor phase of ferro-periclase is much softer than dominate phase of (Mg,Fe)SiO3 perovskite and the resultant bulk rheology is often affected by the weaker phase (e.g. viscosity) even if the volume fraction of weaker phase is small (Handy, 1990; Yamazaki and Karato, 2001).
To characterize the rheology of the lower mantle, we focus on one of most important textures of connectivity each phases of the composite aggregate of (Mg,Fe)SiO3 perovskite and ferro-periclase synthesized by high-pressure experiments. The connectivity of a minor phase is closely related with the bulk rheology when the minor phase is much weaker than the major phase because of the significant reduction in viscosity with a network structure of a weaker phase (Handy, 1994). To investigate the connectivity of ferro-periclase, which is 2-3 orders of magnitude weaker than perovskite, we carried out in situ electric conductivity measurement at high pressure and temperature on the aggregates because the conductivity of ferro-periclase is much higher than that of perovskite. The results show that the interconnected network of ferro-periclase was formed after phase transition from ringwoodite and remained for a while. This indicates that the viscosity in the subducting slab may be controlled by the rheology of ferro-periclase because the interconnected structure is kept for a geological time scale by the extrapolation of experimental results.