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Effect of water and stress on the lattice-preferred orientation of olivine

Haemyeong Jung*
School of Earth and Environmental Sciences, Seoul National University (hjung@snu.ac.kr)

The effect of water and stress on the lattice-preferred orientation (LPO) of olivine aggregates was investigated through large strain, shear deformation experiments at high pressures and temperatures (P = 0.5 - 2.1 GPa, T = 1470 - 1570 K) under both water-poor and water-rich conditions. The specimens are hot-pressed synthetic olivine aggregates or single crystals of olivine. Water was supplied to the sample by decomposition of a mixture of talc and brucite. Deformation experiments were conducted up to γ (shear strain) ~ 6 using the Griggs apparatus where water fugacity was up to ~13 GPa at the pressure of 2 GPa. The water content in olivine saturated with water increases with increasing pressure and the solubility of water in olivine at P = 0.5 - 2 GPa was ~400 - 1200 ppm H/Si. Several new types of LPO in olivine are found depending on water content and stress. Samples deformed in water-poor conditions show a conventional LPO of olivine where the olivine [100] axis is subparallel to the shear direction, the (010) plane subparallel to the shear plane (type-A). However, three new types (type-B, C, and E) of LPO of olivine were identified depending on the water content and stress. The type-B LPO of olivine which was found at relatively high stress and/or under moderate to high water content conditions is characterized by the olivine [001] axis subparallel to the shear direction, the (010) plane subparallel to the shear plane. The type-C LPO which was found at low stress and under water-rich conditions is characterized by the olivine [001] axis subparallel to the shear direction, the (100) plane subparallel to the shear plane. The type-E LPO which was found under low stress and moderate water content is characterized by the olivine [100] axis subparallel to the shear direction, the (001) plane subparallel to the shear plane. Observations by transmission electron microscopy (TEM) and scanning electron microscopy (SEM) show that the dislocations in water-poor samples (type-A) are curved and both **b** = [100] and **b** = [001] dislocations have a similar population. Numerous subgrains are seen in water-poor samples in backscattered electron images. In contrast, water-rich samples (both type-B and type-C) contain mostly **b** = [001] dislocations and dislocations are straight and sub-grain boundaries are rare compared to those in water-poor samples. These observations suggest that (1) dominant slip systems in olivine change with water content (and stress) and (2) grain boundary migration is enhanced in the presence of water. Seismic anisotropy corresponding to the fabrics under water-rich condition is significantly different from that under water-poor condition. Consequently, the relationship between seismic anisotropy and flow geometry in water-rich regions is expected to be different from that in water-poor regions in which type-A fabric dominates (i.e., the lithosphere).