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Microstructural development under diffusion creep of olivine-melt system

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Lattice preferred orientation(LPO) in natural rocks is considered to be generated in deformation of the rocks. For example, seismic velocity anisotropy in the asthenosphere is considered to be the result of LPO which is developed under shear deformation of the mantle. Partial melt is likely to be present in the asthenosphere so it is important to understand the rheology and microstructure of the partial molten mantle rock, in order to know the actual state of the asthenosphere. A number of deformation experiments in olivine-melt system have been conducted demonstrating the formation of variety of LPO patterns(Zimmerman et al. 1999, Holtzman et al. 2003).

In this study, we conducted deformation experiments on olivine-melt system to examine the relationship between their flow characteristic and microstructure. We synthized bulk samples of Fe-free olivine + anorthetic melt(10~20vol%). We used Instron type deformation testing machine equipped with a vertical furnace, and deformed the samples at the strain rate of 10e-5~10e-4/s under the temperature 1260 degrees(Celsius) and atmospheric pressure.

Stress and strain rate relationships were obtained from the stress and displacement rate of the samples during the deformation. The stress exponent approximately equals 1, indicating that the samples deformed under diffusion creep. We also measured the orientation of olivine crystals in the deformed samples by EBSD under FE-SEM, finding alignments of b-axes of olivine to the compression direction. Melt distribution changed by the deformation. Large melt pockets($>$100 micrometer in diameter) elongated normal to the direction of compression whereas small melt pockets at grain junction align parallel to the compression direction. We consider that the elongated melt pockets were formed by the melt deformation following the bulk sample strain whereas the intergranular melt alignments were generated by an infiltration of the melt to olivine grains which were separated to the tensile direction. LPO of the olivine might be resulted from alignments of short axes of olivine grains, which are parallel to the b-axis of the crystal to the direction of compression.

Keywords: diffusion creep, olivine-melt system, LPO