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Microstructural observation on naturally deformed olivine in peridotite

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Deformation microstructures of mantle derived olivine, such as slip system and density of dislocation and recrystallized grain size are strongly influenced by deformation conditions in the mantle. Slip system of dislocation in deformed olivine changes with temperature, water content and stress (Carter and Ave Lallemant, 1970; Jung et al., 2006). And dislocation density and recrystallized grain size also change with stress, which can be used as a geopiezometer (Kohlstedt and Goetze, 1974; Jung and Karato 2001). In this study, we try to estimate the deformation condition and history recorded in the peridotite xenoliths using these microstructures. The samples were collected from 1) Takashima in Saga Pref., Japan 2) Kurose in Fukuoka Pref., Japan 3) Megata in Akita Pref., Japan and 4) Salt Lake in Hawaii, USA.

The slip systems are determined from the patterns of Lattice-Preferred Orientation (LPO), and directly observation of dislocations using Weak-Beam Dark-Field (WBDF) method of TEM. We use SEM with EBSD system and TEM for measurement of LPO, and the dislocation density, respectively. The recrystallized grain size is measured mainly under the optical microscope.

We now obtain the following results. 1) The active slip systems suggested by LPO of Kurose, Megata and Salt Lake are same, which is (010)[100]-A-type, {0kl}[100]-D-type or (001)[100]-E-type. The development of LPO of Takashima is poor, but it probably suggests that it is (010)[001]-B-type or (100)[001]-C. 2) The active slip systems determined by WBDF method are (010)[100]-A-type for Takashima and Salt Lake, and (001)[100]-E-type for Kurose and Megata. These results, except for Takashima, confirm those of LPO measurements. On the basis of the experimental result, we infer that the peridotite xenoliths from Takashima and Salt Lake, and Kurose and Megata were deformed under "low stress and low water content" and "low stress and high water content" conditions, respectively. 3) The stresses estimated from dislocation densitiesy are bigger than those from recrystallized grain size in Megata, Takashima and Salt Lake. It is known that the dislocation density remains constant just after the stress applies, while the recrystallized grain size becomes constant after the strain reaches large. Therefore, these results suggest that the deformation stage of these peridotites were under transient creep, in which the additional stress applied after the steady state creep. On the other hand, the both stresses estimated from dislocation density and recrystallized grain size in Kurose is same, which suggests that these microstructures were created under steady state creep.

Carter and Ave Lallemant (1970) The Geological Society of America, 81, 2181. Jung and Karato (2001) Journal of Structural Geology, 23, 1337. Jung et al. (2006) Tectonophysics, 421, 1. Kohlstedt and Goetze (1974) Journal of Geophysical Research, 79, 2045.

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