Abstract

Garnet peridotite nodules from Bultfontein, South Africa, were investigated in order to obtain information on the lattice preferred orientation (LPO) of the main constituent minerals – olivine and orthopyroxene – and the microstructural evolution of peridotites deformed in an upper mantle shear zone. The studied sample suite contains coarse-grained garnet lherzolite and sheared peridotite xenoliths from kimberlites showing different extent of deformation and recrystallization. The shearing of the coarse-grained peridotites led to a grain-size reduction, as a result of dynamic recrystallization that has been accomplished by bulging and/or subgrain rotation. Compared with the coarse-grained garnet lherzolite, the samples of sheared peridotite contain more orthopyroxene at expense of clinopyroxene (Cpx occurs mainly in association with shearing and dynamic recrystallization of Opx). Olivine in coarse-grained garnet lherzolite (sample SPB9) displays an LPO pattern that may be interpreted as resulting from dislocation glide on (010)[100] (A-type fabric) and orthopyroxene displays an LPO typical of dislocation glide on (100)[010]. The observed LPO of dynamically recrystallized olivine in sheared peridotite samples corresponds with dislocation glide on the following slip systems: 1) (010)[100] – A-type fabric – SPB13, SPB10; 2) (001)[100] – E-type fabric – SPB8a, SPB2a; or 3) "axial (010) pattern" – SPB11a, SPB1a, SPB7, SPB12. Dynamically recrystallized orthopyroxene grains show an LPO patterns reflecting an activation of these slip systems: 1) (100)[001] – SPB8a, SPB2a, SPB13, SPB1a, SPB7; or 2) (010)[001] – SPB10, SPB7, SPB12. As representatives of the different stages of microstructural evolution we have chosen thin sections SPB3a, SPB8a and SPB7. In ***SPB3a (LBF microstructure, beginning of dynamic recrystallization),*** dynamic recrystallization of olivine leads only to scatter of the primary fabric of olivine porphyroclasts. Distribution of strong orthopyroxene domains probably affects the stress field, and so the direction of ductile creep of olivine. Opx grains show kinking and dynamic recrystallization along either original grain or kink band boundaries, and lattice preferred orientation of new Opx grains is usually inherited from parent grains. ***SPB8a (IWL microstructure, intermediate stage of recrystallization)*** is characterized by interconnected fine-grained olivine matrix and its LPO defines orientation of finite strain ellipsoid. Opx porphyroclasts rotate passively in olivine matrix to the position of easy slip on (100)[001]. The parts of kinked Opx grains (kink bands), which come to position indisposed towards easy slip, undergo dynamic recrystallization that results in reaching the final easy slip orientation. The LPO of recrystallized Opx grains in kink bands corresponds to dislocation glide on (100)[001], and the observed striking asymmetry could indicate a strong

simple shear component of deformation. In ***SPB7 (IWL microstructure, advanced recrystallization)*** the fraction of recrystallized grains further increased. Recrystallized Opx grains form elongated domains, which enclose relicts of Opx porphyroclasts. LPO of dynamically recrystallized Ol grains reflects dislocation glide on (010)[001] with subsidiary activation also in [100] direction. LPO of dynamically recrystallized Opx can be interpreted either as a result of dislocation glide on (100)[001], or on (010)[001]. In all described stages, LPO of recrystallized grains is still controlled by the orientation of parent porphyroclasts. This fact suggests that the microstructures are not in their steady state.

The P-T estimates are based on the three recent integrated geothermobarometers of Brey & Köhler (1990), Taylor (1998) and Nimis & Taylor (2000). The estimated P-T conditions for coarse-grained garnet lherzolite range from 797 to 896°C at 29-37 kbar. The estimated P-T conditions of dynamic recrystallization in the samples of sheared garnet peridotite fall within the range of 975-1072°C at 29-38 kbar.

The grain size statistics and the temperature estimates has been used to construct the deformation mechanism maps of olivine for either coarse-grained and also sheared peridotites in order to characterize rheological behaviour of studied rocks. The map shows that increase in temperature during shearing is associated with dramatic strain rate increase (from 10^{-14} to 10^{-10} s^{-1}) and shrink of the diffusion creep field at expense of the dislocation creep. Hence, the palaeopiezometric curve occurs at the boundary between both creeps that prevent effective activation of the grain boundary sliding.