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# Development of olivine crystallographic preferred orientation in response to strain-induced fabric geometry

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The effect of finite strain ellipsoid geometry on crystallographic preferred orientation (CPO) is well known for crustal minerals (e.g., quartz, calcite, biotite, and hornblende). In the upper mantle, however, it remains poorly constrained how strain and fabric may affect olivine CPO. We present data from a suite of 40 spinel peridotite xenoliths from Marie Byrd Land (west Antarctica), which support an interpretation that fabric geometry rather than deformation conditions control the development of olivine CPO. We use X-ray computed tomography (XRCT) to quantitatively determine spinel fabric (orientation and geometry). Olivine CPOs, determined by Electron Backscattered Diffraction (EBSD), are plotted with respect to the XRCT-derived spinel foliation and lineation; this approach allows for the accurate, and unbiased, identification of CPO symmetries and types in mantle xenoliths. The combined XRCT and EBSD data show that the xenoliths are characterized by a range of fabric geometries (from oblate to prolate) and olivine CPO patterns; we recognize the A-type, axial-[010], axial-[100], and B-type patterns. The mantle xenoliths equilibrated at temperatures 779–1198 oC, as determined by 2-Px geothermometry. Using a geotherm consistent with the stability of spinel in all xenoliths, the range of equilibration temperatures occurs at depths between 39 and 72 km. Olivine recrystallized grain size piezometry reveals differential stresses ranging 2–60 MPa. Analysis of low-angle misorientation axes show a wide range in the distribution of rotation axes, with dominant {0kl}[100] slip. We use Fourier Transform Infrared (FTIR) spectroscopy to estimate the water content in the xenolith with the B-type CPO pattern. FTIR analysis shows that the equilibrium H concentration in olivine is low (4-13 ppm $H_2O$). Combining these data, we observe that olivine CPO symmetry is controlled neither by the deformation conditions (stress, temperature, pressure, water content) for the range of conditions estimated in the Marie Byrd Land xenoliths, nor by the activation of the slip systems predicted by deformation experiments. Rather, our data show that olivine CPO is controlled by transitions in strain-induced fabric geometry. Microstructures and deformation mechanism maps suggest that deformation is dominated by dislocation-accommodated grain boundary sliding. We propose that slip of olivine glide planes and rotation of olivine grains occur so as to accommodate the imposed material flow, which is guided by the 3D strain-induced fabric geometry. As a result of this process, the axial-[010] and B-type patterns form in relation to oblate fabric ellipsoids, the A-type pattern forms in a range of fabric ellipsoids, and the axial-[100] pattern is associated with prolate fabric ellipsoids. We therefore suggest that the well-known process of strain geometry-induced development of CPO is also applicable to upper mantle rocks.