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Olivine and spinel fabric development in lineated peridotites

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Investigation of olivine and spinel fabrics in lineated harzburgites from the Red Hills peridotite massif, New Zealand, reveals that the spinel grain population records the same orientation of the principal finite strain axes as olivine grains, however, olivine grains generally record stronger fabric anisotropy. Further, olivine crystallographic preferred orientation (CPO) reflects the constrictional kinematic context of these rocks. In these harzburgites, deformed at ∼1200 ˚C and >6 kbar, spinel grains are variably oriented and display weak to no CPO. Shape fabric in spinels, determined using X-ray computed tomography (XRCT) indicates a range of geometries (L>S, L=S and L<S ellipsoids), with the shape factor ranging from -0.30 (prolate fabric) to +0.55 (oblate fabric). Olivine grains (mean diameter: 0.13 – 0.27 mm) exhibit evidence for dislocation creep, including subgrains, undulose extinction and a strong shape preferred orientation, with long axes parallel or subparallel to the mean spinel long axis orientation derived from XRCT. Olivine fabric analyses, carried out using Image SXM on grain traces from optical photomicrographs of two mutually perpendicular thin sections from each sample, yield moderately to strongly prolate fabrics (L>S tectonites) for olivine in all samples. CPO, plotted with respect to lineation and foliation as defined by XRCT analyses of spinel grains, is characterized by [100] maxima parallel or subparallel to the lineation; [010] and [001] form girdles perpendicular to the lineation, consistent with the D-type CPO for olivine.

Olivine CPO is typically interpreted in the context of deformation conditions (e.g., temperature, stress) based on experimental studies. However, the D-type CPO for olivine is generally associated with deformation at relatively lower temperatures than suggested by the mineral compositions in these rocks. Our data suggest that olivine CPO may not only respond to deformation conditions, but may be controlled by the geometry of the finite strain ellipsoid.

These texture and fabric data suggest that spinel is stronger than olivine at these deformation conditions. The olivine CPO and SPO are consistent with the lineations and foliations as defined by spinel grain geometries, indicating that spinel grains deformed concurrently with the olivine. That the aggregate shape fabric of the spinel grains is consistent with the SPO of the olivine suggests that spinel deformation may be dominated by passive rotation in a weaker matrix. These data indicate that the aggregates of spinel grains do record the orientation of the principal finite strain axes; however, spinel fabric geometry (e.g., prolate vs. oblate fabrics) may deviate from the fabric geometry recorded by the olivine, the dominant mineral in peridotites. Further investigation of the deformation and reaction history of the Red Hills lineated harzburgites may provide further insights into the observed deviation between the spinel and olivine fabric geometries.