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B-type Olivine Fabric induced by Grain Boundary Sliding

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Olivine fabric, or Lattice Preferred Orientation (LPO), in naturally deformed peridotite largely contributes to the seismic anisotropy of the upper mantle. LPO usually results from motion of intra-crystalline dislocations during dislocation creep. In this case, experimental and numerical data indicate that the degree of mineral alignment (fabric strength) increases with increasing finite strain. Here, we show an opposite trend suggesting that olivine fabric can also result from a different deformation mechanism. Based on documentation of olivine LPOs in peridotites of a kilometer-scale mantle shear zone in the Ronda massif (Spain), we highlight a transition from a flow-parallel [a]-axis LPO (A-type fabric) to a flow-normal [a]-axis LPO (B-type fabric). While dislocation sub-structures indicate that A-type fabric results from dislocation motion, we conclude that the B-type fabric does not originate from dislocation creep, but instead from grain boundary sliding (GBS) because: (1) dislocation sub-structures remain consistent with the A-type slip system in all samples; (2) the fabric transition from A-type to B-type correlates with decreasing fabric strength despite increasing finite strain; and (3) our observations are supported by experiments that document B-type fabric in olivine aggregates where deformation involves a component of GBS. The B-type olivine fabric has a specific signature in term of seismic anisotropy, and hence, our results may have important implications for interpreting upper mantle structures and deformation processes via seismic observations.