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Differential lattice preferred at high pressure and temperature

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Our current understanding of plastic deformation via dislocation glide has provided us with a powerful tool for defining paleo-deformation from seismic anisotropy. Conventional wisdom informs us that deformation of a randomly oriented polycrystal results in a polycrystal in which there is a preferred orientation of the grains as controlled by the deformation field and the dislocation slip system. In simple shear, at large strain (>100%), grains rotate so that the Burger's vector (the slip direction) aligns with the shear direction. For olivine, this places the a axis parallel to the flow direction. Longitudinal waves travelling parallel to the a axis and shear waves polarized in the a direction are faster than similar waves traveling with different orientations. Thus, large tectonic deformations of olivine rich material can leave an imprint via seismic anisotropy of the geometry of the deformation event with data from shear wave splitting or other manifestations of seismic anisotropy. However, the effects of small strains or changes in the strain field remain as important questions.

Here we report results of a proof-of-concept study of 'differential LPO' with MgO and olivine samples. In this study, we place the sample at high pressure (a few GPa) and high temperature (up to 1600C) and subject it to a sinusoidally varying uniaxial stress. We demonstrate the correlation between stress and texture formation. Differential stress is measured from the X-ray diffraction pattern using the multi-element detector. The texture evolution is indicated by the intensity of the diffraction peaks MgO (111), (200) and (220). We show here that there is a strong LPO signal that has the same periodicity as the driving stress. We suggest that this is a usable signal for defining a differential LPO, that is an LPO resulting from small changes in the stress/strain field, and that this differential LPO can help delineate relative effeciencies of various regions of parameter space for generating an LPO from flow. Furthermore, we demonstrate that the LPO is consistent with macroscopic models of polycrystalline deformation.