The anisotropic signature of tectonic boundaries in the mantle

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The study of seismic anisotropy provides our best observational constraints into the patterns of mantle flow and convection within the Earth's interior through the development of deformation-induced lattice preferred orientation (LPO) of olivine. Most studies of mantle anisotropy rely on either receiver-based techniques (e.g. SKS splitting) that only provide information directly beneath a seismic receiver, or surface wave studies which tend to average laterally. Neither technique is well adapted to studying sharp lateral boundaries in the mantle, particularly in the middle of oceans, such as those that might exist at plate boundaries and mid-ocean ridges. Here we present investigations of mantle anisotropy from a range of novel techniques (source-side splitting, PS splitting, and Quasi-Love waves) that new provide point-based measurements of mantle deformation within the typically inaccessible ocean basins and continental margins. We find that oceanic transform faults display an anisotropic signature distinct from the wider plate-mantle system. Geodynamic modelling of anisotropy development at a mid-ocean-ridge with a 3D Ridge-Transform-Ridge geometry reveals that oceanic transform faults represent discontinuity-like features in the mantle as two opposing mantle flow directions are accommodated across the boundary, with a component of mantle upwelling in the centre. This distinct signature appears to be preserved in the mantle beneath fracture zones, the along-strike continuation of oceanic transform faults. Other regions which appear to display strong mantle anisotropic gradients include continental margins, plate boundaries, geological terrane boundaries, and large igneous provinces. Combined these observations suggest that many tectonic processes and features visible at the Earth's surface are preserved over time and with depth (up to 100-200km) in the mantle through the development and conservation of anisotropy.