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Depth rotations of azimuthal seismic anisotropy associated with relative importance of Couette/Poiseuille flow in the asthenosphere

Zhirui Ray Wang[1], Clinton P. Conrad[2], Sergei Lebedev[3], Giampiero Iaffaldano[4], and John R. Hopper[5,6]

[1]Department of Earth and Environmental Sciences, LMU Munich, Germany (Zhirui.Wang@lmu.de)
[2]Centre for Planetary Habitability (PHAB), University of Oslo, Norway
[3]Department of Earth Sciences, University of Cambridge, United Kingdom
[4]Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Italy
[5]Department of Geophysics and Sedimentary Basins, Geological Survey of Denmark and Greenland, Denmark
[6]Department of Geosciences and Natural Resource Management, University of Copenhagen, Denmark

Azimuthal seismic anisotropy in the upper mantle is crucial for understanding the spatial patterns of past and present upper mantle deformation. Traditional interpretation of such anisotropy attributes to relative shear between surface plates and mantle. This requires the orientation of anisotropy azimuths to remain constant with depth. However, inferences of azimuthal anisotropy based on surface wave tomographic models often reveals depth-dependent azimuths. To this end, the existence of mechanically weak, thin asthenosphere beneath the lithosphere facilitates the channelization of plate-driven Couette flow and pressure-driven Poiseuille flow. The combination of two flows, especially when misaligned, yields depth rotations of asthenospheric shear. This provides a geodynamically plausible link between asthenospheric flow properties and depth rotations of azimuthal seismic anisotropy. In this submission, we utilize publicly available azimuthal seismic anisotropy models together with predictions from a global mantle flow model that incorporates Couette/Poiseuille flow. We find that Poiseuille flow profoundly affects depth rotations of seismically inferred azimuthal anisotropy. Prominent depth rotations are under the Atlantic basin and the Nazca plate, where Poiseuille flow dominates the modeled asthenospheric flow regime. Significant Poiseuille flow may exist beneath the Indian basin, yet with small depth rotation, probably because of its directional alignment with Couette flow. Our results indicate that interpretation of azimuthal seismic anisotropy cannot be simply tied to relative shearing between plates and mantle. Instead, the relative importance of Couette and Poiseuille flows must be taken into account.