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Mid-mantle seismic anisotropy patterns around subduction zones predicted by numerical modelling

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There is increasing evidence for mid mantle seismic anisotropy around subduction zones whose interpretation remains elusive. In this study I estimate the strain-induced mid mantle fabric and associated seismic anisotropy developing in 3D petrological-thermo-mechanical subduction models where the slab is either stagnating over the 660 km discontinuity or penetrating into the lower mantle. The modeling of synthetic lattice-preferred-orientation (LPO) development of wadsleyite and perovskite has been calibrated with results from deformational experiments and ab-initio atomic scale models, and the single crystal elastic tensor of the different mineral phases is scaled by local P–T conditions. The lower transition zone (ringwoodite + garnet) is assumed to be isotropic. Mid mantle fabric develops in proximity of the subducting slab where deformation and stresses are high, except at depths where upwelling or downwelling material undergoes phase transformations, yielding to LPO reset. The upper transition zone (wadsleyite + garnet) is characterized by weak transverse isotropy (2–3%) with symmetry axes oriented and fast S wave polarized dip-normal. A slightly stronger transverse isotropy develops in the lower mantle (perovskite + periclase), where the symmetry axes, the polarization of the fast S wave and the maximum Vp and dVs are parallel to the slab dip and subduction direction. For stagnating slab models this translates into negative and positive radial anisotropy in the upper transition zone and lower mantle back-arc, respectively, minimum delay times for vertically travelling shear waves and large shear wave splitting for waves propagating horizontally in the lower mantle. These results may help in reconciling the seismic anisotropy patterns observed in some subduction zones with subduction-induced deformation, such as those measured in the mid mantle between the Australian plate and the New Hebrides–Tonga-Kermadec trenches that I interpret as related to stagnating portions of the subducted Pacific plate.