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Development of seismic anisotropy during subduction-induced mantle flow

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Subduction zones are convergent margins where the rigid lithosphere sinks into the Earth's mantle inducing complex 3D flow patterns. Seismic anisotropy generated by strain-induced lattice/crystal preferred orientation (LPO/CPO) of intrinsically anisotropic minerals is commonly used to study flow in the mantle and its relations with plate motions.

We present a new methodology to compute the seismic anisotropy directly from the flow in the upper mantle of 3-D numerical models of Earth-like subduction. This computational strategy accounts for the non-steady-state evolution of subduction zones yielding mantle fabrics that are more consistent with the deformation history than previously considered.

In the subduction models a strong mantle fabric develops throughout the upper mantle with a magnitude of the anisotropy that is proportional to the amount of subduction, and is independent of the subduction rate.

The subslab upper mantle is characterized by two domains with different fabrics: at shallow depth the mantle entrained with the subducting slab develops trench-perpendicular directed anisotropy due to simple shear deformation, while in the deeper mantle slab rollback induces pure shear deformation causing trench-parallel extension and fast seismic directions. Subducting plate advance favours the development of the fabric in the entrained mantle domain, while slab retreat increases the trench-parallel anisotropy in the deeper upper mantle. In the deeper domain the strength of the fabric is proportional to the horizontal divergence of the flow and weakens from the slab edges toward the centre. As such, strong trench-parallel anisotropy forms below retreating and relatively narrow slabs or at the margins of wider plates.

The synthetic SKS splitting patterns calculated in the fore-arc are controlled by the magnitude of the anisotropy in the upper domain, with trench-perpendicular fast azimuths in the centre of large plates and trench-parallel toward the plate edges. Instead, above relatively narrow, retreating slabs ($\leq$ 600 km and low subduction partitioning ratio (SPR)), azimuths are trench-parallel due to the strong anisotropy in the lower subslab domain.

In all models the anisotropy in the back-arc and on the sides of the subducting plate is, respectively, trench-perpendicular and sub-parallel to the return flow at depth. Results from our regional scale models may help to infer the flow and composition of the upper mantle by comparison with the wide range of subduction zones seismic data observed globally