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Upper and mid mantle fabric developing 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 computed the seismic anisotropy of the upper and mid mantle due to strain-induced LPO in 3D mechanical models of dynamic subduction by using, respectively, D-Rex and Underworld. Subsequently, FSTRACK was used to compute seismogram synthetics and SKS splitting patterns.

Strong anisotropy develops in the upper mantle, while weak or null seismic anisotropy is formed in the upper transition zone/lower mantle and lower transition zone, respectively. The distribution of the fabric in the mantle depends on the distribution and amount of the deformation, and not on the rate at which the slab subducts.

The SKS splitting patterns are controlled by the anisotropy in the upper mantle because SKS waves are more sensitive to the anisotropy in the shallowest layers.

Horizontally propagating shear waves in the mid mantle originating from local earthquakes are characterized by significant splitting that is mostly due to the fabric in the uppermost lower mantle.

We discuss the implications of our results for real subduction settings like Tonga, where a discrete amount of observations have been collected in the past 10 years on the anisotropy in the upper and mid mantle.