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A perspective on seismic anisotropy in the oceanic asthenosphere and its implication on mantle fabric and subduction zone flow field

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Subduction of oceanic asthenosphere is a simple concept to link the fabric of oceanic asthenosphere and subduction zone flow field [Song and Kawakatsu, 2012, GRL (SK12)]. The fundamental of this scenario relies on the details of anisotropy symmetry in the oceanic asthenosphere how it manifests in various seismic observables such as multiple S waves radial anisotropy, surface wave radial anisotropy, azimuthal anisotropy and shear wave splitting. By construction, we can build a suite of elastic tensors with orthorhombic symmetry that are consistent with all observations. Starting with a simple 2D entrained flow beneath the slab, we previously examined the prediction of shear wave splitting behaviors against slab geometry observed in a global scale as well as regional scale (e.g., Alaska; Song and Kawakatsu, 2013, EPSL). We found that trench-parallel (trench-normal) average fast splitting direction can be mostly associated with steep (shallow) subduction geometry as the influence of slow symmetry axis takes over at relatively high angles.

While typical A-type olivine fabric is dominated by hexagonal symmetry (or orthorhombic symmetry) with a fast symmetry axis, the elastic tensor(s) constructed by SK12 for oceanic asthenosphere is dominated by a vertical slow symmetry axis, similar to AG type fabrics discussed in the literatures (e.g., Mainprice, 2007), resulting a strong radial anisotropy over relatively weak azimuthal anisotropy. As a consequence, the splitting behavior is not as uniform as predicted by the A-type fabric. Instead, it is not only incident angle dependent, but also varying with ray back azimuth. As source-side S wave splitting observations become available, the predictions with respect to these observations will be presented and discussed considering different mantle reference frames.

We further revisit the preferred asthenospheric fabric against various seismic observations such as receiver functions beneath the oceanic plate and the bottom of subducting slab as well as observations of SS precursors. The preferred model associated with the lithosphere-asthenosphere boundary (or LAB) appears involves AG-type LPO and a larger melt fraction than the bulk asthenosphere. These inferences will be discussed against several mechanisms including melt-solid interaction [e.g., Holtzman et al., 2003], simultaneous activation of different slip systems [e.g., Ohuchi et al., 2011] or/and transpression deformation [e.g., Tommasi et al., 1999] that may introduce AG-type LPO