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The influence of near-vertical SK(K)S ray path incidence on the backazimuthal variation of shear-wave splitting parameters: A case study in the Pacific Northwest

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Content
The occurrence of seismic anisotropy, e.g. the spatial behavior of shear-wave splitting (SWS) parameters (φ, δt), has been studied widely in various regions. While lattice-preferred orientation (LPO) of upper mantle minerals, such as orthorhombic olivine and orthopyroxene, is known as the main source of SWS in SK(K)S observations, it is still to be determined, to which degree the nature of azimuthal anisotropy is due to frozen-in-deformation in the lithosphere or to recent geodynamic activities in the asthenosphere. In this study, we use the near-vertical SWS approach, introduced by Davis (2003), to address this key problem. A Taylor-series expansion of the angular eigenvector dependence in the Christoffel equation allows analyzing the backazimuthal (baz) variation of φ in the case when the incidence angle of SK(K)S phases is not vertical. φ then has a baz variation of 180° periodicity and a polarity depending on the d_1 parameter, which is related to the foliation orientation. We distinguish between olivine having a vertical b-axis (“b-up”), as may be associated with the Simple Asthenospheric Flow (SAF) model, or c-axis (“c-up”) as may be expected for a Vertical Coherent Deformaton (VCD) in the lithosphere. Applying the Mainprice (1990) code, implemented in MSAT, enables us to compare the baz behavior of φ and δt, obtained from the near-vertical SWS approach, with the results from numerical geodynamic modeling. Based on the SWS dataset of IRIS DMC for North America, mostly from USArray stations but also from other networks (Liu et al., 2014), we explain our procedure to select, group and cluster suitable stations, which leads us to an investigation of the Pacific Northwest region. The d_1 parameters are calculated from the SWS-baz dependence first; to explain polarity changes, we further compute d_1 for upper mantle particles in geodynamic models of the Cascadia Subduction Zone fabric, generated by an updated version of the D-Rex code of Kaminski et al. (2004). Comparing these findings with the foliation orientation, determined from the modeled fabric, we relate the resolved variation in d_1 polarity to changes in the mantle flow field.

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