Anisotropy and XKS-splitting from geodynamic models of double subduction: Testing the limits of interpretation

J. P. Kruse*[1], G. Rümpker[1], F. Link[1,2], T. Duretz[1], H. Schmeling[1]

1. Institute of Geoscience, Goethe University Frankfurt, Germany
2. Department of Geology and Geophysics, Yale University, United States

DOI: http://dx.doi.org/10.17169/refubium-41052

In this study, we develop three-dimensional geodynamic models to predict XKS-splitting for double subduction scenarios characterized by two outward dipping slabs. These models are highly relevant in various realistic settings, such as the central Mediterranean. We focus on the analysis of XKS-splitting, a key geophysical observable used to infer seismic anisotropy and mantle flow patterns predicted from these geodynamic models. Our geodynamic models simulate the concurrent subduction of two identical oceanic plates which are separated by a continental plate. The variation of the separating plate strength, cause a transition from a retreating to a stationary trench. The models provide detailed insights into the temporal evolution of mantle flow patterns, especially the amount of trench parallel flow, induced by these double subduction scenarios. In a second step, we use the well-known D-Rex model (Kaminski et al., 2004) to efficiently estimate the CPO development in response to plastic deformation produced by mantle flow. Based on the results of the D-Rex model, which includes the full elastic tensor of a deformed multiphase polycrystalline mantle aggregate within the three-dimensional model, we obtain synthetic apparent splitting parameters at receivers placed at the surface by applying multiple-layer anisotropic waveform modeling. Employing analytical techniques, we show the ambiguous nature of apparent splitting parameters, as already suggested by previous studies based on numerical modeling. In the light of the results, we postulate that a meaningful inversion, based on the commonly applied 2-layer anisotropic model, requires additional constraints on fast-axis orientation or strength of anisotropy (delay time). Finally, we show that constraints from our texture simulations (i.e., the integrated delay time) can be used to achieve unique 2-layer models that perfectly fit the synthetic observables. Such models could serve as reference for the interpretation of the observations. Our study highlights the necessity of combining geodynamic modeling and XKS-splitting analysis to shed light on complex upper mantle flow patterns such as those that might occur around subduction zones.

Kaminski, É., Ribe, N. M., Browaeys, J. T., 2004. D-Rex, a Program for Calculation of Seismic Anisotropy Due to Crystal Lattice Preferred Orientation in the Convective Upper Mantle, Geophysical Journal International, vol. 158, no. 2, pp. 744–52, doi:10.1111/j.1365-246X.2004.02308.x