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Constraining Crustal Anisotropy by Receiver Functions at the Deep Continental Drilling Site KTB in Southern Germany

Irene Bianchi, Ehsan Qorbani, and Götz Bokelmann
University of Vienna, Wien, Austria (irene.bianchi@univie.ac.at)

As one of the rare observational tools for studying deformation and stress within the Earth, seismic anisotropy has been one of the focuses of geophysical studies over the last decade. In order to unravel the anisotropic properties of the crust, the teleseismic receiver functions (RF) methodology has started to be widely applied recently. Such effects of anisotropy on RF were illustrated in theoretical studies, showing the strong backazimuthal dependence of RF on the 3D characteristics of the media sampled by the waves. The use of teleseismic RF has the advantage of not being affected by a heterogeneous depth distribution of local earthquakes, since teleseismic rays sample the entire crust beneath the stations. The application of this technique however, needs to be critically assessed using a suitable field test.

To test the technique, we need a crustal block where the underground structure is reasonably well-known, e.g., where there is extensive knowledge from local seismic experiments and drilling. A field experiment has thus been carried out around the KTB (Kontinental Tiefbohrung) site in the Oberpfalz area in Southeastern Germany, in order to compare with previous results from deep drilling, and high-frequency seismic experiments around the drill site.

The investigated region has been studied extensively by local geophysical experiments, and geological studies. The deep borehole was placed into gneiss rocks of the Zone Erbendorf-Vohenstrauss. The drilling activity lasted from 1987 to 1994, and descended down to a depth of 9101 meters, sampling an alternating sequence of paragneiss and amphibolite, with metamorphism of upper amphibolite facies conditions, and ductile deformation produced a strong foliation of the rocks.

The application of the RFs reveals strong seismic anisotropy in the upper crust related to the so-called Erbendorf body.

The SKS shear-wave splitting method has been applied as well, revealing coherent results for the whole region with exception of the southernmost station, for which the seismic waves show larger delays. We use the RF observations to test the effect of crustal anisotropy on the SKS records, which sample entire crust and upper mantle.