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The role of propagation direction and particle motion of S-waves propagating through anisotropic rocks: an experimental study

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As a result of penetrative flow, metamorphic terranes show planar structures such as slaty cleavage, schistosity, and foliation and are often pervasive for tens to hundreds of kilometres. In such rocks, preferred orientation of minerals and cracks are widely prevalent, and the crust is highly anisotropic to seismic waves. For an understanding and interpretation of seismic anisotropy and shear wave splitting in the Earth´s crust, laboratory studies on crustal rocks are therefore of great importance.

This poster focuses on the directional dependence of P- and S-wave propagation and polarisation in foliated crustal rocks, based on experimental and theoretical investigations. Two medium-grained foliated core samples of hbl-bio gneiss and amphibolite from the Kola superdeep well were selected for the investigation. We measured simultaneously P- and S-wave velocities (S1, S2) on sample cubes in three orthogonal directions as a function of pressure, and we calculated the 3D-velocity distribution from measured lattice preferred orientation (LPO) and the known single crystal properties.

The seismic measurements were done in a multi-anvil pressure apparatus using the ultrasonic pulse transmission technique to pressure of 600 MPa. Emphasis is placed on the relative angle of the incoming propagating waves with respect to the orientation of the foliation and lineation. For the hbl-bio gneiss sample, the three orthogonal measuring directions were in accordance with the structural frame **X, Y, Z** defined by foliation and lineation, whereas for the amphibolite sample the structural reference frame is tilted, separating the measuring directions **A, B, C** from the **X, Y, Z** axes. The LPO of major minerals is obtained by U-stage and neutron diffraction measurements, respectively. The spatial distribution of P-and S-wave velocities were calculated from the ODFs reconstructed from the sets of experimental polefigures and corresponding single crystal elastic constants. The LPO-based numerical velocity calculations give important information on the different contribution of the various rock-forming minerals to the intrinsic elastic anisotropy and confirm the close relationship between seismic properties (velocity anisotropy, shear wave splitting and shear wave polarisation) and the structural frame of the rocks seen in the experiments. Comparison of measured with calculated velocities obtained for the three propagation directions **X, Y, Z** and **A, B, C,** respectively, demonstrates that for shear waves propagating through anisotropic rocks the vibration directions are as important as the propagation directions. Proper measurement of shear wave splitting by means of two orthogonal polarised sending and receiving shear wave transducers is only possible when their propagation and polarisation directions are parallel and normal to foliation and lineation, respectively.