SEISMIC ANISOTROPY AND ITS IMPACT ON IMAGING THE ALPINE FAULT: AN EXPERIMENTAL AND MODELLING PERSPECTIVE

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Seismic methods are used to develop our understanding of fault zone geometry and to infer its physical properties. Seismic wave anisotropy can be significant in fault zones due to structural characteristics such as the spatial distribution, texture, and crystallographic preferred orientation (CPO) of minerals (i.e., tectonite fabric tensor), as well as fractures and regional stress variation. Still, a quantitative treatment of seismic anisotropy that would allow imaging of fault zones from reflection or passive seismic data is rare. Here we combine experimental and numerical methods to establish the implications of elastic wave anisotropy in a quartzofeldspathic mylonite for seismic imaging of the Alpine Fault.

P-wave elastic wave anisotropy of the mylonite is estimated by common experimental methods, namely ultrasonic wave propagation under confining pressure and numerical modelling based on scanning electron backscattered diffraction (EBSD) data. EBSD-modelled anisotropy is estimated from the (static) effective media elastic tensor following a Voigt–Reuss–Hill averaging (MTEX) and with dynamic simulation of wave propagation using finite element modelling (FEM). The numerical results show a 16–20% anisotropy based on two EBSD sections. The FEM results show a lower slow P-wave velocity compared to MTEX as the method is sensitive to both CPO and the spatial distribution of minerals. Moreover, the dynamic nature of the FEM allows simulating scattered and guided waves. The laboratory measurements show much higher anisotropy (27% and 31% at pressures equivalent to 15 km and 5 km depth, respectively), because micro-cracks remain open at pressures representative of the Alpine Fault seismogenic zone. Our study shows wave speeds that match those from Alpine Fault Drilling Project (DFDP-2) sonic logs, providing an explanation of the identified low velocity zones. Finally, we show that in the brittle regime high seismic reflectivity at near-vertical incidence to the fault plane can be explained by accounting for elastic wave anisotropy and foliation-parallel fractures identified in our experimental study.