Reconciling experimental and static-dynamic numerical estimations of seismic anisotropy in Alpine Fault mylonites

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Quartzo-feldspathic mylonites and schists are the main contributors to seismic wave anisotropy in the vicinity of the Alpine Fault (New Zealand). We must determine how the physical properties of rocks like these influence elastic wave anisotropy if we want to unravel both the reasons for heterogeneous seismic wave propagation, and interpret deformation processes in fault zones. To study such controls on velocity anisotropy we can: 1) experimentally measure elastic wave anisotropy on cores at in-situ conditions or 2) estimate wave velocities by static (effective medium averaging) or dynamic (finite element) modelling based on EBSD data or photomicrographs. Here we compare all three approaches in study of schist and mylonite samples from the Alpine Fault.

Volumetric proportions of intrinsically anisotropic micas in cleavage domains and comparatively isotropic quartz+feldspar in microlithons commonly vary significantly within one sample. Our analysis examines the effects of these phases and their arrangement, and further addresses how heterogeneity influences elastic wave anisotropy. We compare P-wave seismic anisotropy estimates based on millimetres-scale ultrasonic waves under in situ conditions, with simulations that account for micrometre-scale variations in elastic properties of constitutent minerals with the MTEX toolbox and finite-element wave propagation on EBSD images. We observe that the sorts of variations in the distribution of micas and quartz+feldspar within any one of our real core samples can change the elastic wave anisotropy by 10%. In addition, at 60 MPa confining pressure, experimental elastic anisotropy is greater than modelled anisotropy, which could indicate that open microfractures dramatically influence seismic wave anisotropy in the top 3 to 4 km of the crust, or be related to the different resolutions of the two methods.