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Explaining transient microstructures from the base of the seismogenic zone. What gives: experiment, nature or mechanism models?

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A study of brittle-ductile shear zones from the base of a fossil seismogenic zone, in the Southern Alps of New Zealand, provides a model for the processes that may occur during short-lived deformation at transiently-high stresses at mid-crustal depths; but the data also raise many questions as to how we use microstructural observations of natural samples, together with laboratory experimental data to make realistic models of rock deformation in nature.

We measured the crystallographic preferred orientations (CPOs) and microstructures of deformed quartz veins that have undergone ductile shear to finite shear-strains of 5 – 10 in these late Cenozoic shear zones, at temperatures of 450 $\pm$ 50ºC, pressures of 310 $\pm$ 90 MPa and strain-rates between 2*10^{-12} and 2*10^{-9} s^{-1}. Optical microscopy, together with electron backscattered diffraction, reveal that the microstructure in the sheared veins is polygonal and annealed in appearance, with few subgrains and an average grain-size of $\sim$ 100 μm. The microstructure of veins in the wall rocks to shear zones is very similar to that in the shear zones. The CPO of the quartz veins is random to very weak within the shear zones. One sample has a strong CPO outside of the shear zone, related to a Mesozoic foliation in the wall rock. That CPO is destroyed within the shear zone.

Any deformation mechanism model for these shear zones that is consistent with existing understanding of microstructural development and with laboratory data is complicated: our favoured model requires several mechanism changes. Simpler, single mechanism, microstructural models are possible, but they require huge errors in estimates of natural conditions or in the extrapolations of laboratory data to natural conditions.