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The importance of strain localisation in shear zones

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The occurrence of various types of shear bands (C, C', C") in shear zones indicate that heterogeneity of strain is common in strongly deformed rocks. However, the importance of strain localisation is difficult to ascertain if suitable strain markers are lacking, which is usually the case. Numerical modelling with the finite-element method has so far not given much insight in the development of shear bands. We suggest that this is not only because the modelled strains are often not high enough, but also because this technique (that usually assumes isotropic material properties within elements) does not properly incorporate mineral deformation behaviour.
We simulated high-strain, simple-shear deformation in single- and polyphase materials with a full-field theory (FFT) model coupled to the Elle modelling platform (www.elle.ws; Lebensohn 2001; Bons et al. 2008). The FFT-approach simulates visco-plastic deformation by dislocation glide, taking into account the different available slip systems and their critical resolved shear stresses in relations to the applied stresses. Griera et al. (2011; 2013) have shown that this approach is particularly well suited for strongly anisotropic minerals, such as mica and ice Ih (Llorens 2015). We modelled single- and polyphase composites of minerals with different anisotropies and strengths, roughly equivalent to minerals such as ice Ih, mica, quartz and feldspar. Single-phase polycrystalline aggregates show distinct heterogeneity of strain rate, especially in case of ice Ih, which is mechanically close to mica (see also Griera et al. 2015). Finite strain distributions are heterogeneous as well, but the patterns may differ from that of the strain rate distribution. Dynamic recrystallisation, however, usually masks any strain and strain rate localisation (Llorens 2015). In case of polyphase aggregates, equivalent to e.g. a granite, we observe extensive localisation in both syn- and antithetic shear bands. The antithetic shear bands are, however, ephemeral and best seen in movies. In the final microstructure they are very difficult to discern.
We present movies that show that in all cases the distribution of both strain rate and of finite strain is much more heterogeneous than the finite microstructure tends to show.

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