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Modelling of deformation and recrystallisation microstructures in rocks and ice

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Microstructures both record the deformation history of a rock and strongly control its mechanical properties. As microstructures in natural rocks only show the final "post-mortem" state, geologists have attempted to simulate the development of microstructures with experiments and later numerical models. Especially in-situ experiments have given enormous insight, as time-lapse movies could reveal the full history of a microstructure. Numerical modelling is an alternative approach to simulate and follow the change in microstructure with time, unconstrained by experimental limitations. Numerical models have been applied to a range of microstructural processes, such as grain growth, dynamic recrystallisation, porphyroblast rotation, vein growth, formation of mylonitic fabrics, etc. The numerical platform "Elle" (www.elle.ws) in particular has brought progress in the simulation of microstructural development as it is specifically designed to include the competition between simultaneously operating processes.

Three developments significantly improve our capability to simulate microstructural evolution: (1) model input from the mapping of crystallographic orientation with EBSD or the automatic fabric analyser, (2) measurement of grain size and crystallographic preferred orientation evolution using neutron diffraction experiments and (3) the implementation of the full-field Fast Fourier Transform (FFT) solver for modelling anisotropic crystal-plastic deformation. The latter enables the detailed modelling of stress and strain as a function of local crystallographic orientation, which has a strong effect on strain localisation such as, for example, the formation of shear bands. These models can now be compared with the temporal evolution of crystallographic orientation distributions in in-situ experiments. In the last decade, the possibility to combine experiments with numerical simulations has allowed not only verification and refinement of the numerical simulation technique but also increased significantly the ability to predict and/or interpret natural microstructures. This contribution will present the most recent developments in in-situ and numerical modelling of deformation and recrystallisation microstructures in rocks and in ice.