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Utilizing microstructural characteristics to derive insights into deformation and annealing behaviour: Numerical simulations, experiments and nature

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Understanding the influence of the pre-existing microstructure on subsequent microstructural development is pivotal for the correct interpretation of rocks and ice that stayed at high homologous temperatures over a significant period of time. The microstructural behaviour of these materials through time has an important bearing on the interpretation of characteristics such as grain size, for example, using grain size statistics to detect former high strain zones that remain at high temperatures but low stress.

We present a coupled experimental and modelling approach to better understand the evolution of recrystallization characteristics as a function of deformation-annealing time paths in a material with a high viscoplastic anisotropy e.g. polycrystalline ice and magnesium alloys. Deformation microstructures such as crystal bending, subgrain boundaries, grain size variation significantly influence the deformation and annealing behaviour of crystalline material.

For numerical simulations we utilize the microdynamic modelling platform, Elle (www.elle.ws), taking local microstructural evolution into account to simulate the following processes: recovery within grains, rotational recrystallization, grain boundary migration and nucleation. We first test the validity of the numerical simulations against experiments, and then use the model to interpret microstructural features in natural examples. In-situ experiments are performed on laboratory grown and deformed ice and magnesium alloy. Our natural example is a deformed then recrystallized anorthosite from SW Greenland.
The presented approach can be applied to many other minerals and crystalline materials.