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Deformation and Annealing Microstructures in ice: Laboratory Experiments, detailed microstructural analysis and numerical modelling

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Here we present data from several experimentally deformed samples of laboratory grown columnar ice. Detailed microstructural analyses using high resolution EBSD reveal that (a) inhomogeneous deformation through the grains is translated into lattice distortions that are concentrated mainly at grain boundaries and triple junctions,
(b) these distortions may be continuous or may form distinct, straight tilt boundaries that commonly cross whole grains and occur as near parallel arrays and subgrains of 10-50 micron size. These boundaries form mainly by rearrangement of basal edge dislocations into low energy configurations (i.e. tilt boundaries) in various prism planes. Continuous lattice distortions commonly originate from screw or mixed edge and screw dislocations lying in the basal plane.
Subsequent annealing at -4 ºC for 4 hrs results in significant, but traceable changes of the microstructure. These include (i) disappearance of subgrains with former misorientation of less than 2º, (ii) survival and increase in misorientation of some but not all distinct, straight subgrain boundaries, (iii) nucleation of small, new grains in areas of high continuous distortion (i.e. triple junctions) and (iv) grain boundary migration between adjacent grains with velocities of ~20 microns/hr.
To investigate the underlying principles of annealing, we performed numerical modelling in which subgrain boundaries are treated as arrays of dislocations. These are allowed to rearranged and/or dissipate if it is energetically favourable. Furthermore, grain boundary migration is modelled as a function local surface energy and dislocation density.