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How to recognise post-deformational annealing at the subgrain scale: In-situ annealing experiments and numerical simulation.

V.E. Borthwick (1), S. Piazolo (1), G.M. Pennock (2), P.D. Bons (3), L.A. Evans (4), and C.J. Peach (2)

(1) Department of Geology and Geochemistry, Stockholm University, Stockholm, Sweden (verity.borthwick@geo.su.se), (2) Department of Earth Sciences, Utrecht University, Utrecht, The Netherlands, (3) Institut für Geowissenschaften, University of Tübingen, Tübingen, Germany, (4) Department of Earth Sciences, The University of Melbourne, Melbourne, Australia

Recognising post-deformational annealing is key to interpreting rheological adjustments after deformation. The focus of this study is to use coupled in-situ experimental techniques with numerical simulation to increase understanding of substructure dynamics in a geological material, and as a consequence recognise microstructures formed during post-deformational annealing.

In-situ annealing experiments have been conducted in the Scanning Electron Microscope, using Electron Backscatter Diffraction (EBSD) to collect information about the crystallographic orientation of the surface. A single crystal of halite, pre-deformed under uniaxial compression at temperatures of ∼450 ºC with a strain rate of 6.9x10-6s-1, and to a final strain of 0.165, was examined. Different temperature time-paths were investigated with temperatures between 280-470 ºC and durations of heating between 30 min and 6 h. EBSD maps were taken before, during and after heating. Behaviour during annealing was found to be temperature dependent and could be divided into three main phases of development. Subgrain boundaries could be divided into five categories based on behaviour during annealing, morphology and orientation. Observations could be directly linked to the variable mobility of two groups of dislocations introduced during deformation, as well as temperature control on dislocation glide and climb. We infer that the dislocation budget throughout annealing changed significantly, with respect to both ratio of dislocation types, as well as their location in the substructure. We thus suggest that by investigating the dislocation budget of a system with known deformation geometry the temperature of annealing can potentially be established.

In conjunction with experimentation, development of a numerical model for the processes occurring during annealing has also been undertaken. The experiments were directly compared to the simulation in order to improve the model. A first attempt at modelling the behaviour in the experiments applied a phase field method of gradient reduction. While the model did reproduce some of the results from the experiments, including the subdivision of subgrains into areas of like orientation, it did not realistically replicate other features. To combat the limitations presented by this method a new model is being developed, focusing on new techniques in dislocation density and burgers vector calculation. Information from the experimental results will be used in the development of the code. Once this model is able to reproduce behaviour observed in the experiments it can be used to model the substructure dynamics at a variety of conditions and within other materials.