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Strain localisation during diffusion creep: influence of grain coarsening and grain boundary sliding

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Diffusion creep and the wet low temperature version, pressure solution, are major deformation mechanisms in the Earth. Pressure solution operates in many metamorphosing systems in the crust and may contribute to slow creep on fault surfaces. Diffusion creep prevails in areas of the upper mantle deforming slowly, and possibly in most of the lower mantle. Both mechanisms contribute to localisation since small grain sizes can deform faster.

However, there has been limited attention paid to the evolution of microstructure during diffusion creep. In some experiments grains coarsen; in some but not all experiments grains remain rather equant. We have developed a grain-scale numerical model for diffusion creep, which indicates that those processes are very important in influencing evolving strength. Our models illustrate three behaviours.

- Strain localises along slip surfaces formed by aligned grain boundaries on all scales. This affects overall strength.
- Diffusion creep is predicted to produce elongate grains and then the overall aggregate has intense mechanical anisotropy. Thus strength during diffusion creep, and localisation on weak zones, is influenced not just by grain size but by other aspects of microstructure.
- Grain coarsening increases grain size and strength. Our most recent work shows how it interacts with ongoing deformation. In particular grain growth can lead to particular grain shapes which are directly related to strain rate, and influence strength. Consequently, understanding localisation during diffusion creep must encompass the effects of diffusion itself, grain boundary sliding and grain coarsening.