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Models for diffusion creep – the destroyer of crystallographic preferred orientation?

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High-strain deformation by pressure solution or diffusion creep is difficult to attain in laboratory experiments, due to the slow strain rates and fine grain sizes required. In the Earth, though, diffusion creep is though to be an important deformation mechanism, and may accommodate high strains. Numerical modelling is one way to extrapolate our understanding. Laboratory experiments provide a test of the theories of diffusion creep – for example, if creep is diffusion-limited, theory predicts that strain rate is proportional to the inverse cube of grain size, and this is what is found in some but not all experiments. The microstructural evolution during diffusion creep is important for modifying rock strength and also has been hypothesised as a method of destroying previously formed crystallographic preferred orientations (CPO), by causing large and disorganised grain rotations.

We present the first numerical test of this hypothesis. The program "DiffForm" simulates diffusion creep at the scale of individual grains, and allows prediction of microstructural evolution, grain rotation and strength evolution. It assumes that creep is limited by diffusion along grain boundaries, and that those boundaries can slip easily and cannot support shear stress. In pure shear we show that microstructures with very regular grain shapes do not give rise to grain rotation (not surprising due to the initial symmetry of the microstructure). Slightly irregular networks give rise to some rotations, and more irregular networks to more. However the rate of rotation decreases with time. In simple shear an array of hexagonal grains, each of which has one side parallel to the shear plane, shows minor rotations. If the same array is rotated 30 degrees initially, then about 30 degrees of actual rotation occurs during shear, as if the process aligns one set of grain boundaries parallel to the shear plane and then reaches steady state. In all simulations to date, grain rotations occur but seem to decay with

time – suggesting that a pre-existing CPO would become smeared out in a predictable way, but not destroyed completely.

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