Geophysical Research Abstracts
Vol. 16, EGU2014-5846, 2014
EGU General Assembly 2014

Diffusion creep in the mantle may *create* and *maintain* anisotropy

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Diffusion creep is thought to play an important role in lower mantle deformation and hence must be understood in detail if Earth behaviour is to be explained. It is commonly claimed that diffusion creep gives rise to equant grain shapes and destroys any crystallographic preferred orientation (CPO), so all physical properties would be isotropic. Some experiments on olivine support the first assertion but other minerals, and polyphase rocks, commonly show inequant grain shapes in nature and experiment even when diffusion creep is thought to be a major contribution to strain.

Numerical models allow rigorous exploration of the effects of deformation under conditions not easily reached in experiments. A numerical model named “DiffForm” (Wheeler & Ford 2007) gives insight into how grain shapes and microstructures evolve during diffusion creep. Modelling shows that whilst grains may initially rotate in apparently chaotic fashion during diffusion creep, such rotations slow down as grains become inequant. Consequently, an initial CPO (formed, for example, by dislocation creep at higher strain rates) will be decreased in intensity but not destroyed. Seismic anisotropy will decrease but not disappear (Wheeler 2009).

Diffusion creep is also predicted to have intense mechanical anisotropy. In simple models diffusion creep is controlled entirely by diffusion and sliding along grain boundaries; there is no crystallographic influence. An aggregate of equant grains must then be mechanically isotropic, but a model microstructure with inequant grains has marked mechanical anisotropy (Wheeler 2010) - an effect related to the fact that grain boundary sliding is an intrinsic part of diffusion creep. That work was based on a very simple microstructure with a single inequant grain shape but I present here new results showing that for more complicated microstructures, mechanical anisotropy is intense even for quite modest grain elongations. There will be feedback between strain and rheology which may control overall mantle strength.

This theoretical development and some recent experiments indicate that diffusion creep is quite a different process to what was envisaged 10 years ago. This means that its relationship to seismic and mechanical anisotropy in the Earth requires reappraisal.

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