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Diffusion creep in mafic rocks – microstructural and textural features

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Diffusion creep, realized via dissolution precipitation creep (DPC), occurs over a wide temperature range in rock deformation. DPC may be particularly important close to the brittle-viscous transition (BVT) when temperatures are too low to activate dislocation creep in certain minerals.
Here we present rock deformation experiments on 'wet' plagioclase (Pl) - pyroxene (Px) mixtures at T = 800 °C, P = 1.0 and 1.5 GPa and strain rates of $\sim$ 3 e-5 1/s, performed with a Griggs-type solid medium deformation apparatus. At these conditions, the sample material is close to its BVT but deforms dominantly viscous as indicated by the mechanical data. Two sample materials will be discussed, a Pl(Ab40) + Orthopyroxene + Augite mixture (from natural Maryland Diabase), and a synthetic mixture of Pl(Ab99) + Enstatite.

The main deformation mechanisms are identified to be grain boundary sliding (GBS) and DPC. Intracrystalline deformation, such as dislocation glide and –creep, is not seen to occur. Strain in the samples is localized in anastomosing shear bands where diffusion creep (DPC+GBS) is enabled by the intense grain size reduction caused by the nucleation of new grains, replacing porphyroclasts of the starting material. Nucleation in the case of the Maryland Diabase material is accompanied by mineral reactions of, e.g. , Pl(Ab40) + Px + H_2O to form Amphibole (Amp) + Quartz. In the case of the Pl(Ab99) + Enstatite mixture, Albite porphyroclasts are replaced by neo-crystallized Albite grains without a detectable change in solid-solution composition.

Two main, syn-kinematic microstructural features will be discussed:
(i) The development of a weak but consistent Albite crystallographic preferred orientation within shear bands during diffusion creep. The texture thereby is defined by an alignment of [001] within the shear plane and poles to (010) at a high angle to it.
(ii) The evolution of Amp reaction coronas. During the hydrostatic pre-deformation stage of an experiment, Amp coronas are observed to grow symmetrically around Px porphyroclasts. When a differential stress is applied, corona thickness decreases at high stress sites and simultaneously increases at low stress sites, a feature highly suggestive of deformation by DPC. DPC is frequently described for naturally deformed Amp but has been rarely reproduced in experiments until now.