Geophysical Research Abstracts, Vol. 8, 06145, 2006
SRef-ID: 1607-7962/gra/EGU06-A-06145
© European Geosciences Union 2006

Dynamic grain growth in laboratory experiments, microstructural modelling and naturally deformed rocks

A. Kellermann Slotemaker and **J.H.P. de Bresser**

HPT Laboratory, Department of Earth Sciences, Utrecht University, Budapestlaan 4, Utrecht 3584 CD, the Netherlands (arthur@geo.uu.nl, j.h.p.debresser@geo.uu.nl)

Grain size is one of the parameters that can be of great importance in controlling the ductile flow of rocks. One way of estimating the strength of rocks under natural conditions is to make use of rheological flow laws; these may or may not be grain size dependent. Flow laws have been calibrated for a wide range of crustal and mantle materials, based on data produced by extensive deformation testing in the laboratory. In general, rock flow laws do not explicitly take into account transient effects resulting from progressive modification of the microstructure during deformation. However, gradual changes in microstructure are commonplace in natural settings, demonstrating that it is important to have a grip on the consequences of microstructure evolution. This is the focus of the present study. One well-known and widely studied fabric modification process is progressive grain size refinement resulting from dynamic recrystallization. A process that has received less attention is grain growth due to surface energy driven grain boundary migration (SED-GBM). This process may harden the rock, affecting its role in localizing strain in the long term. With the aim of looking into the effects of grain growth during deformation, we have experimentally investigated the strength and microstructural evolution of fine-grained rock material that coarsens in grain size while deforming by grain size sensitive creep. For this, we used synthetic forsterite and Fe-bearing olivine aggregates (grain size ˜ 0.6 mu), axially shortened at elevated pressure (600 MPa) and temperature (850-1000 °C). Further, we studied microstructural evolution in simple two-dimensional numerical models, combining deformation and SED-GBM by means of the modelling package ELLE. Finally, we applied the inferences from the laboratory and modelling work to naturally deformed rocks, in particular to selected calcite mylonites from the Swiss Alps.

The synthetic olivine samples that were heat treated in the laboratory without straining showed only minor grain growth. In contrast, samples heat-treated and deformed for time durations similar to those of the static tests showed an increase in grain size with increasing strain up to a value twice that of the fully static counterpart. This grain coarsening was associated with continuous hardening of the material, witnessed by the stress-strain curves. A dynamic grain growth model involving an increase in the fraction of non-hexagonal grains, related to grain neighbour switching, appears applicable to the observed grain growth. The ELLE numerical modeling demonstrated that a combination of SED-GBM and geometrical deformation of a 2D grain aggregate can indeed result in enhanced grain growth compared to static grain growth runs. The fraction of non-hexagonal grains was found to remain more or less constant during static grain growth but increased during deformation. Fractions of non-hexagonal grains measured in the naturally deformed rocks from the Alps increased with increasing temperature and grain size, inferred to be related to an increase in contribution of grain size sensitive creep mechanisms to the overall straining. We conclude that the application of a dynamic grain growth model to the long-term microstructural evolution of fine-grained mylonitic rocks can further improve our understanding of the transient or permanent character of rheological behaviour, thereby helping reliable extrapolation of laboratory data to nature.