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Diffusion creep microstructures: analysing spatial distributions

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One of the distinguishing features of diffusion creep microstructures is the spatial distribution of minerals grains. As grains of one phase nucleate and grow between grains of other phases the resulting microstructures tend to become "anticlustered" patterns. This contribution is about finding descriptors by which clustered, random and anti-clustered spatial distributions can be quantified and distinguished from one another.

Studies of the eclogites of the Troms Nappe (Caledonides, Norway) indicate that the dominant deformation mechanism is diffusion creep (see contribution by Stunitz et al., this section). In the course of field observations we collected a large dataset of random and non-random 2-D geometries and compared it to results from 3-D numerical modelling. Starting with the Markov Chain analysis by Kretz (1970) we formulated two models for random spatial distributions: one based on the relative amount of grain boundary surface (surface model) and one based on the relative volume fraction of each phase (volume model). In both cases, if the aggregate consists of two phases (A and B), the relative amounts of grain contacts (AA, BB and AB) follow a binomial distribution.

Because of the different grains sizes of omphacite and garnet, the eclogites were evaluated using the surface model. It can be shown that their microstructures deviate from spatial random distributions showing various degrees of anticlustering and in many cases, the degree of anticlustering depends on direction, being stronger in the direction of the stretching lineation than in direction of the foliation normal. From this we infer that diffusion creep occurred by solution-precipitation processes and heterogeneous nucleation.

A more general model for random distribution considers only one phase (A) and two types of grain contacts (AA and AB, where B is the "matrix"). This model is based on fragmenting a cluster of grains into smaller clusters. It predicts the most probable distribution of cluster sizes and the probability for contact types AA and AB.

A comparison of the three models for random spatial distribution of grains shows that the discrimination of random from non-random patterns and the associated statistics depend strongly on the assumptions made concerning the nature of the underlying random process.