

Diffusion creep microstructures: analysing spatial distributions

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DEFORMATION MECHANISMS

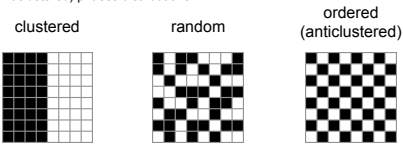
Different deformation mechanisms tend to develop different **spatial distributions** of phases.

Granular flow and grain boundary sliding typically lead to **random** mixing of grains (and phases).

Heterogeneous nucleation or crack seal mechanisms may lead to **ordered** (anticlustered) phases distributions.

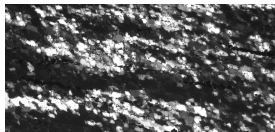
Dynamic recrystallization (rotation recrystallization and grain boundary migration) usually produce **clustered** distributions of newly recrystallized grains.

Here we are interested in the identification and discrimination of random to ordered patterns.

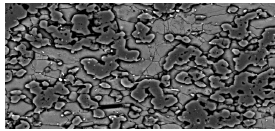


MICROSTRUCTURES

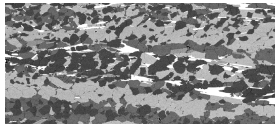
CLUSTERED
Dynamically recrystallized Black Hills Quartzite (LM / circular polarization).
Experimental deformation, subgrain rotation recrystallization, orientation domains.



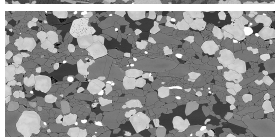
RANDOM - ORDERED
Layer of dolomite - calcite (50:50), natural deformation, Carrara (SEM / BSE).
Alternations of dolomite with calcite precipitates.



CLUSTERED - RANDOM - ORDERED
Truzzo granite, natural deformation (SEM / BSE).
Layers of qtz-ksp, qtz-plag, pure ksp, qtz-ksp-bio



ORDERED
Eclogite, Erzgebirge, natural deformation (SEM / BSE).
Omphacite, garnet, rutile, quartz.



CONCEPTUAL MODELS FOR SPATIAL DISTRIBUTIONS GEOMETRY - METHOD OF ANALYSIS

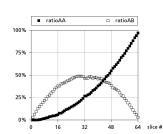
2-D chess



Pre-existing 2-D chess board or Voronoi polygons. Phases (black or white) are assigned (ex post) via random numbering.

The probability for a field of the chess board or the Voronoi tessellation to be A or B can vary from 0 to 1.
 $p_A + p_B = 1$

Contact frequency



For the random chess boards, the binomial distribution is realized

For all models, the phase boundaries AB (between A and B) and grain boundaries AA and BB are calculated.

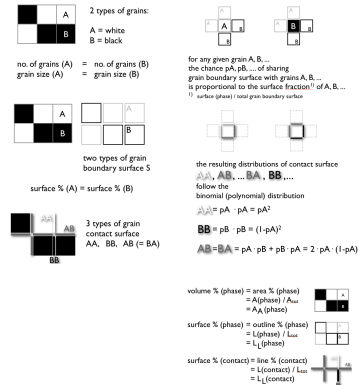
3-D volume or surface model

VOLUME MODEL

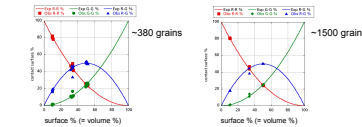
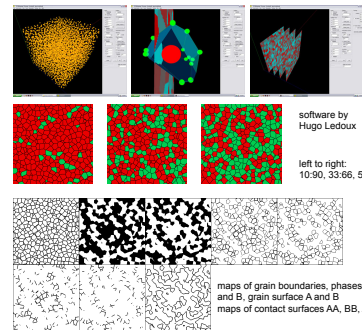
Constant grain size is assumed.
=> probability for a neighbour of phase A depends on volume proportion of A.

SURFACE MODEL

No assumption about grain size.
=> probability for a neighbour of phase A depends on surface proportion of A.



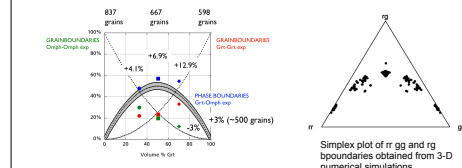
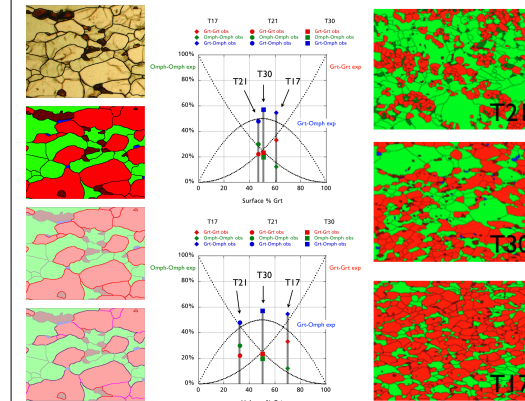
3-D numerical simulation



For the sections of the random 3-D Voronoi, the relative amounts of grain contacts (AA, BB and AB) follow a binomial distribution. Because of constant average grain size, the volume proportions and the surface proportions of both phases are identical.

ANALYSIS AND INTERPRETATION

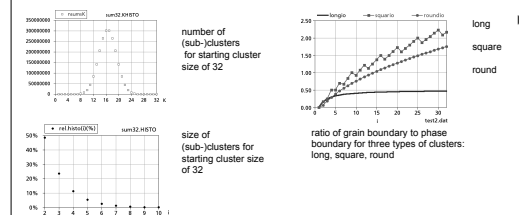
Grain and phase boundary surface %



errors

Since AA, BB and AB always add up to 100%, the error has to be calculated as in compositional data. This, however, is work in progress.

fragmentation model (integer sums)



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 phase A into smaller clusters. It predicts the most probable distribution of cluster sizes and the probability for contact types AA and AB.