Do local kinematics have an effect on the recrystallized grain size piezometer?

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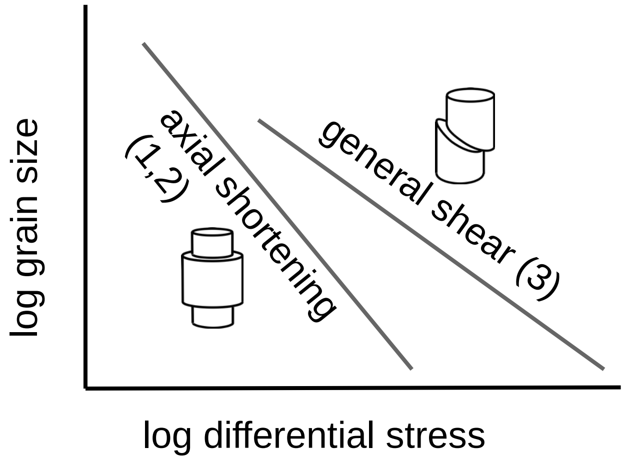
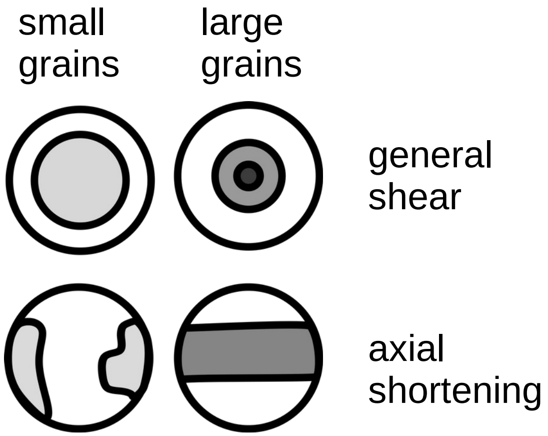
What we find in the literature:



Different relations between differential stress and recrystallized grain size in axial shortening and general shear experiments.

What we want to discuss:



Crystal dispersion axes: In axial shortening experiments, distributions of crystal dispersion axes (vorticity axes?) vary as a function of grain size. What are the implications?

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(1,2) Stipp & Tullis, 2003; Cross et.al., 2017 (3) Heilbronner & Kilian, 2017

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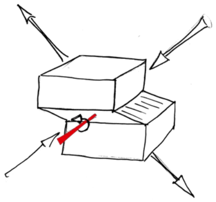
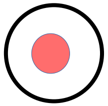
general shear experiments:

- samples > 80 % recrystallized

- crystal dispersion axes align, independent on grain size fraction, parallel to the inferred vorticity axis in the sample



sketch of position of
expected dispersion axes



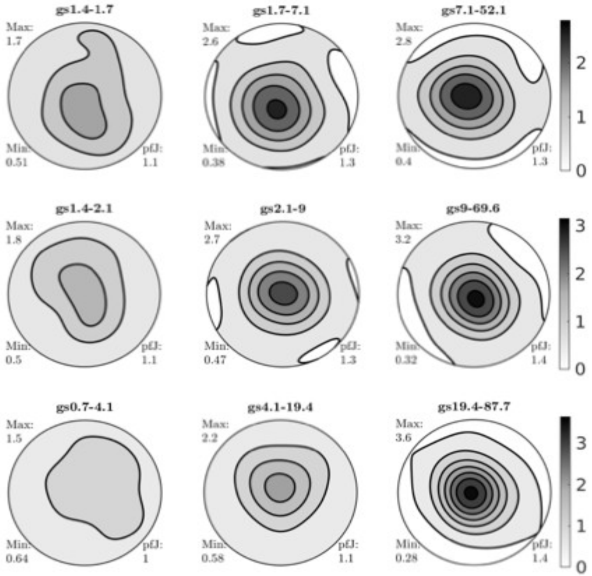
crystal dispersion axes

small grains → large grains

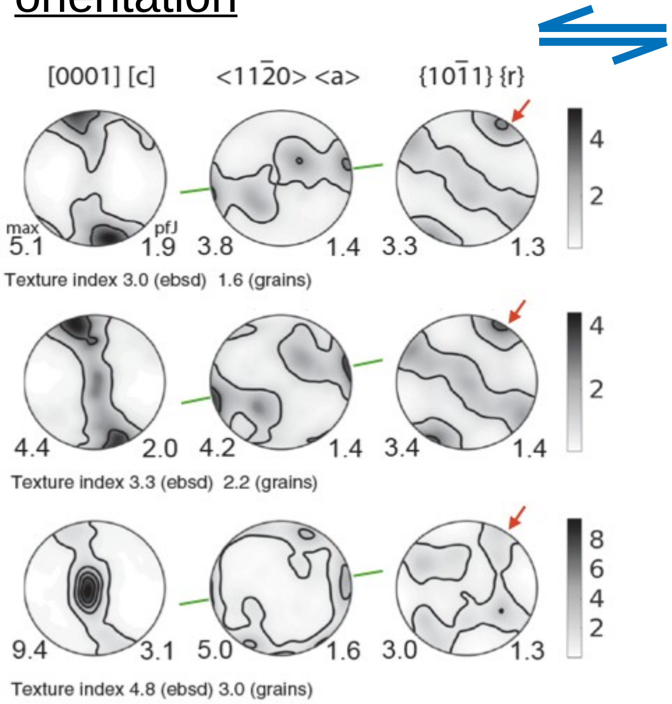
high stress

medium stress

low stress



crystallographic preferred orientation



Kilian & Heilbronner, 2017

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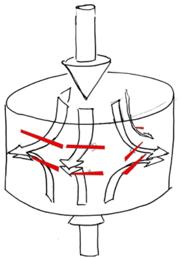
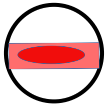
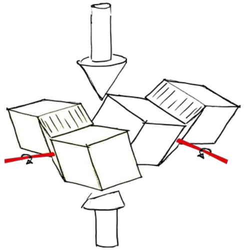
axial shortening experiments:

- samples < 50% recrystallized
- crystal dispersion axes of large grains → strong girdles
small grains → weak point maxima

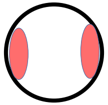


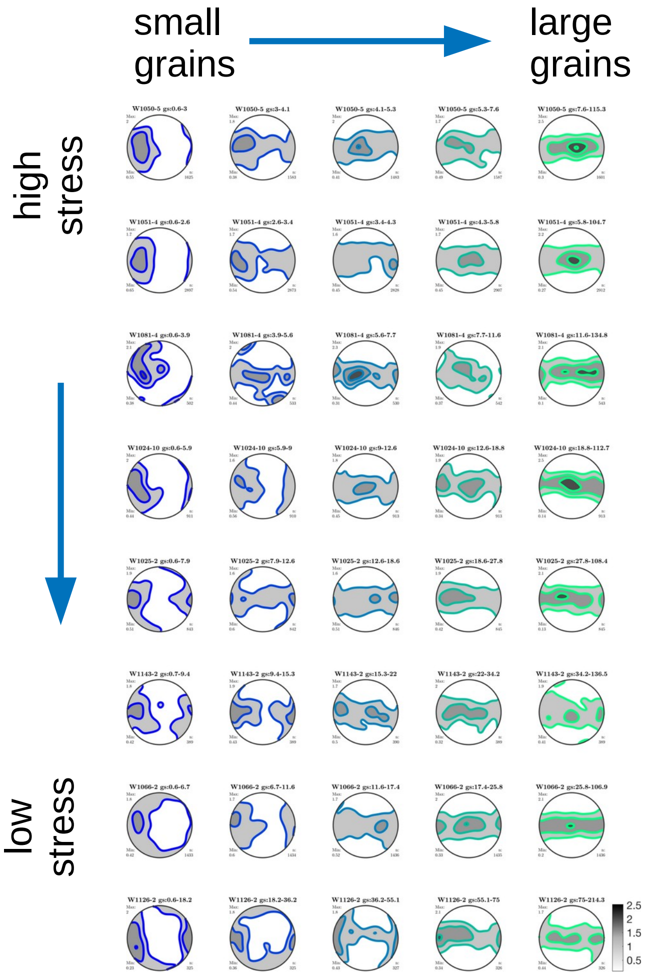
sketch of radial flow pattern, idealized directions of dispersion axes (central cut)

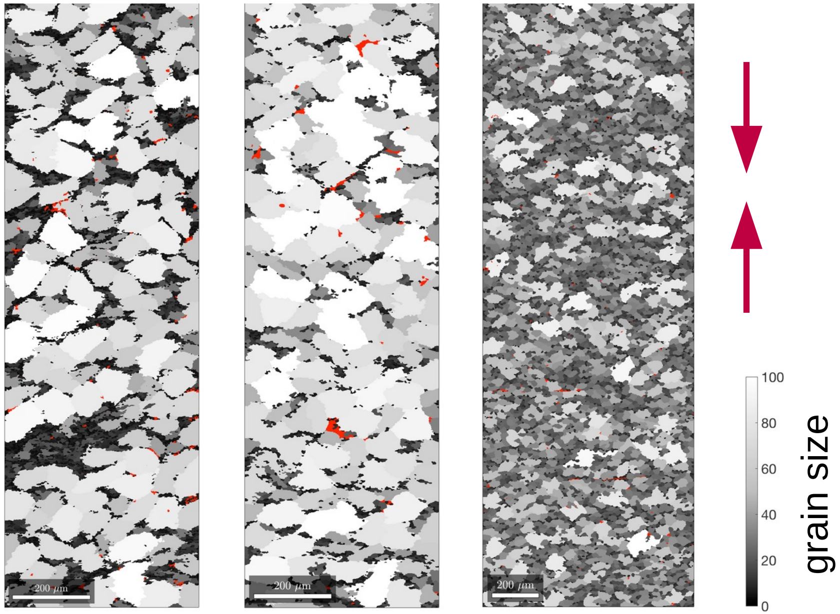




sketch of local shear zones, expected dispersion axis (central cut)







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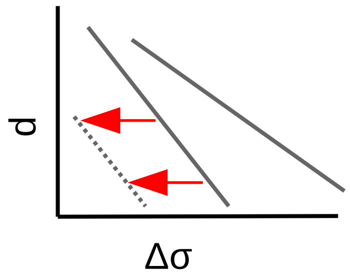
Distributions of dispersion axes in the <u>general shear experiments</u>:
→ no change in direction as a function of grain size

Distributions of dispersion axes in the <u>axial shortening experiments</u>:
→ large grains “see” the globally imposed deformation (girdle)
→ small grains form weak point maxima (localized deformation zones?)

Possible implication?

If large grains act as a load bearing framework, <u>stresses derived from the grain size piezometer would actually be an upper bound</u> – separating grain size - stress correlations of both types of experiments even more*.



More implications?

- large grains are “survivors” which are able to slip while others recrystallize?
- distributions of dispersion axes of small grains are always weaker
  - → less lattice bending?
  - → more rigid body rotation?

Discuss!

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*assuming that mechanical data of general shear experiments are corrected properly

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References:
Cross, A., Prior, D., Stipp, M., Kidder, S., The recrystallized grain size piezometer for quartz: An EBSD-based calibration, Geophysical Research Letters, 44/13, 2017, https://doi.org/10.1002/2017GL073836
Heilbronner, R., Kilian, R., The grain size(s) of Black Hills Quartzite deformed in the dislocation creep regime, Solid Earth, 8, 1071–1093, 2017, https://doi.org/10.5194/se-8-1071-2017
Kilian, R., Heilbronner, R.,Analysis of crystallographic preferred orientations of experimentally deformed Black Hills Quartzite, Solid Earth, 8, 1095–1117, 2017, https://doi.org/10.5194/se-8-1095-2017
Stipp, M., Tullis, J., The recrystallized grain size piezometer for quartz, Geophysical Research Letters, 30/21, 2003, https://doi.org/10.1029/2003GL018444