Relation of quartz c-axis pole figures to deformation processes and flow

Rüdiger Kilian[1], Luiz Morales[2], Geoffrey Lloyd[3], Michael Stipp[1] (1: MLU Halle, Germany; 2: ETH Zürich, Switzerland; 3: University of Leeds, UK)

EGU 21-14508

Issue: quartz CPO -> <u>empirically</u> related to

- strain geometry
- strain magnitude
- flow
- temperature
- ...
-

however, it is often unclear IF an observation is a 1st order relation, merely a coincidence or truly controlled by a physical process.

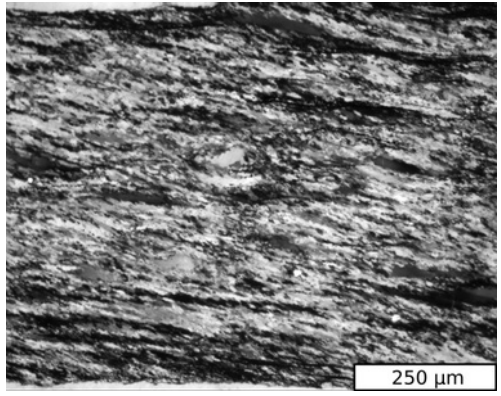
Approach:

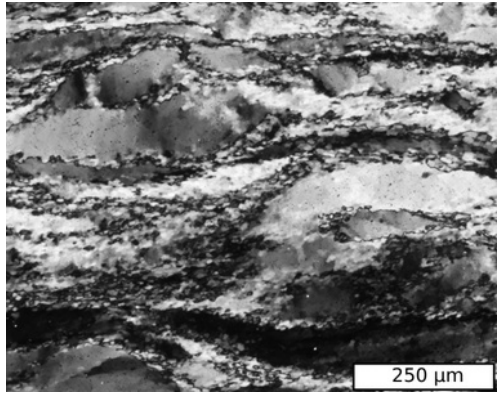
- decompose CPO based on simple microstructural criteria
- find those parameters which control individual CPO components

We test 3 different samples:

- experimentally deformed BHQ [1,2]
- Eriboll quartz mylonite
- deformed quartz vein from the Tonale line [3]

Results >>
Conclusions >>





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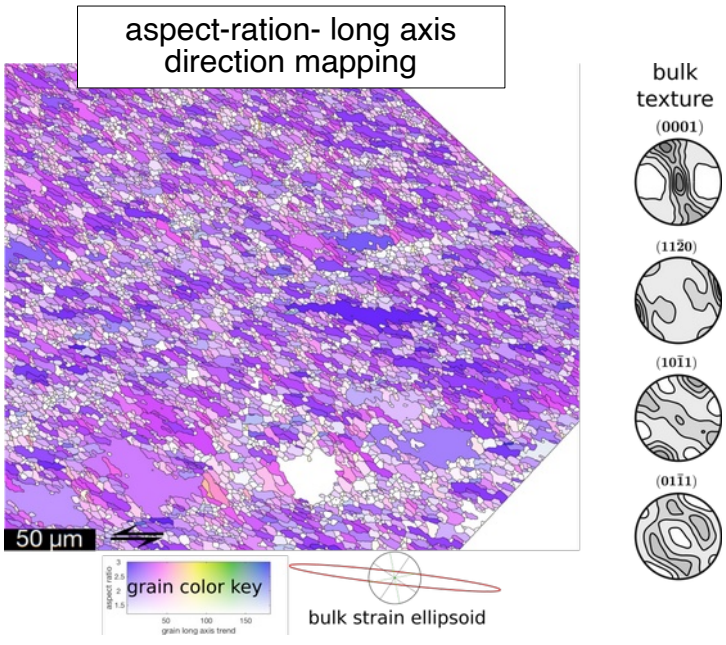
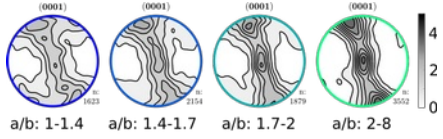
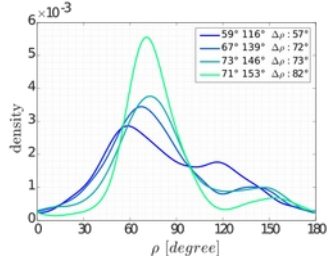
Example 1: experimentally deformed BHQ* [1,2]

*w946 [1] (875°/3*10^{-5}s^{-1},1.5GPa)



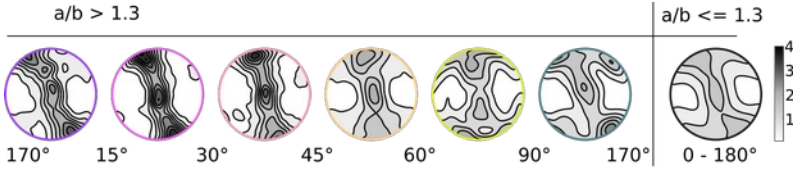
CPO as function of aspect ratio

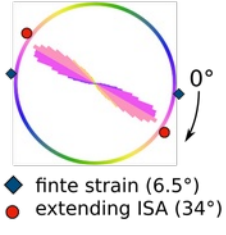


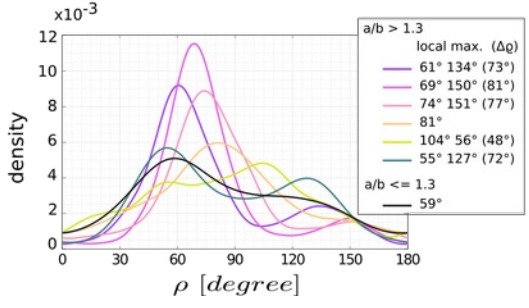


radial density of (0001) pf

CPO as function of ellipse long axis direction ω

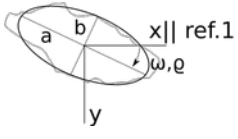




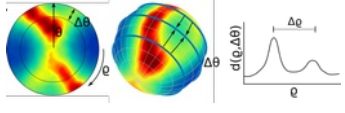


Definitions:

best-fit ellipse parameters



radial pole density



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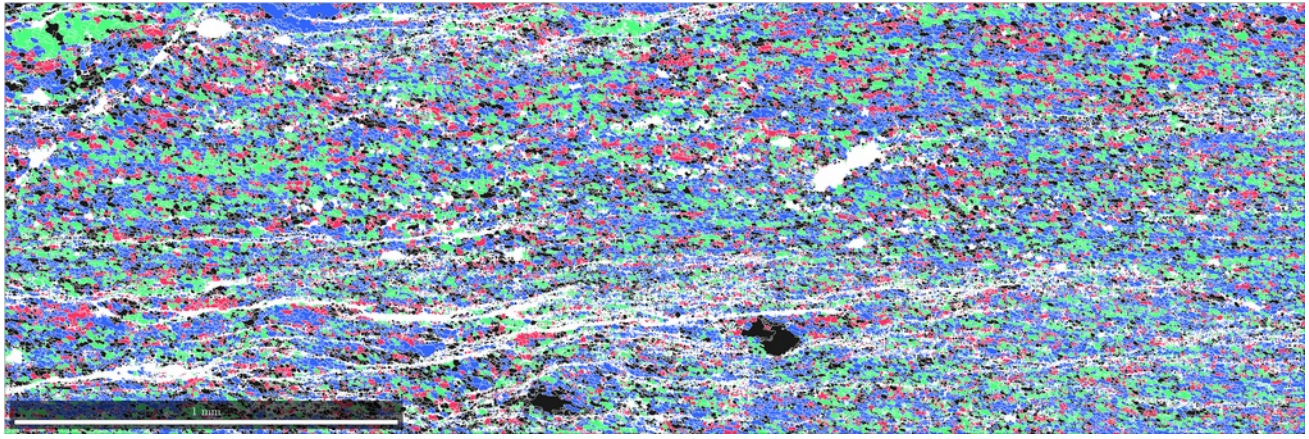
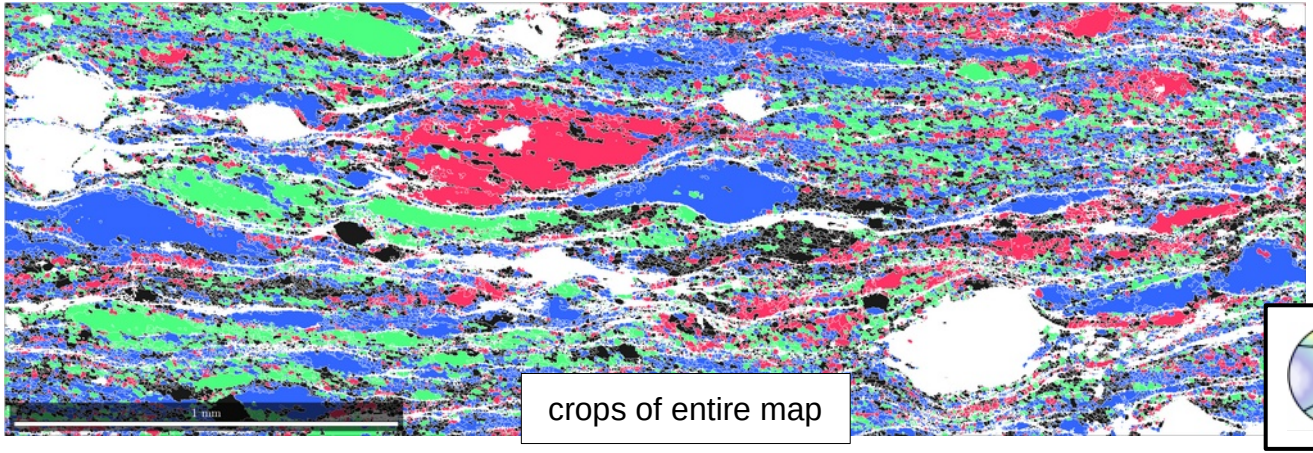
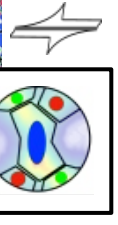
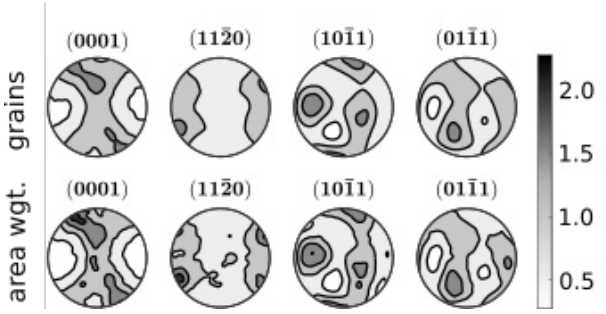
Example 2: Eriboll quartzite mylonite





crops of entire map





EBSD data courtesy of G. Lloyd, Leeds:

- single sample 3.4 x 15 k map at 1 μm
- variable, (non-domainal) microstructure
- large number of grains

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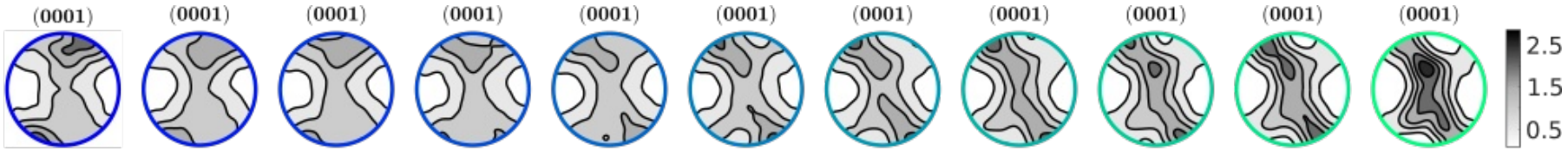
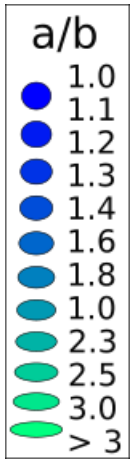
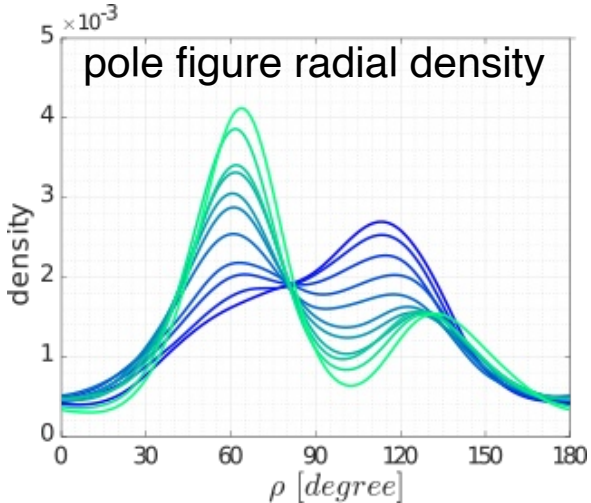
Example 2: Eriboll quartzite mylonite

relation between texture and grain properties: aspect ratio

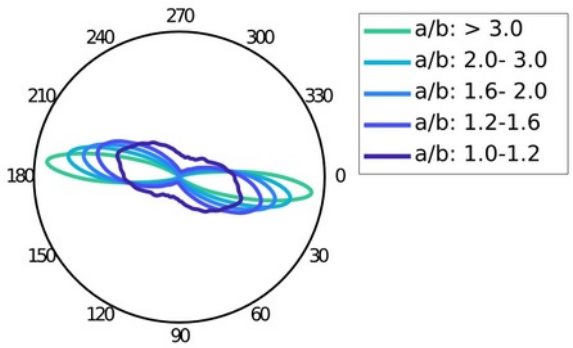


a/b	<1.1	1.1-1.2	1.2-1.3	1.3-1.4	1.4-1.6	1.6-1.8	1.8-2	2-2.25	2.25-2.5	2.5-3	>3
n	8925	22582	29529	31321	59156	40929	27490	21367	11848	9819	3954
“opening angle” [°]		41	50	55	56	61	63	67	65	67	68





long axis direction as function of aspect ratio



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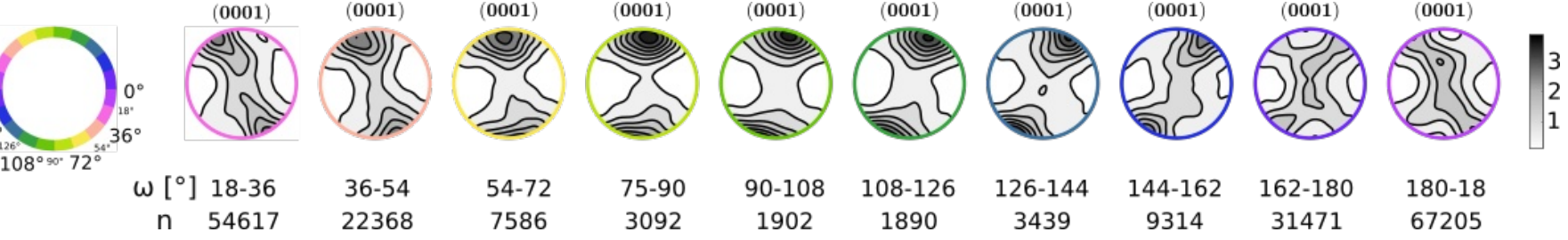
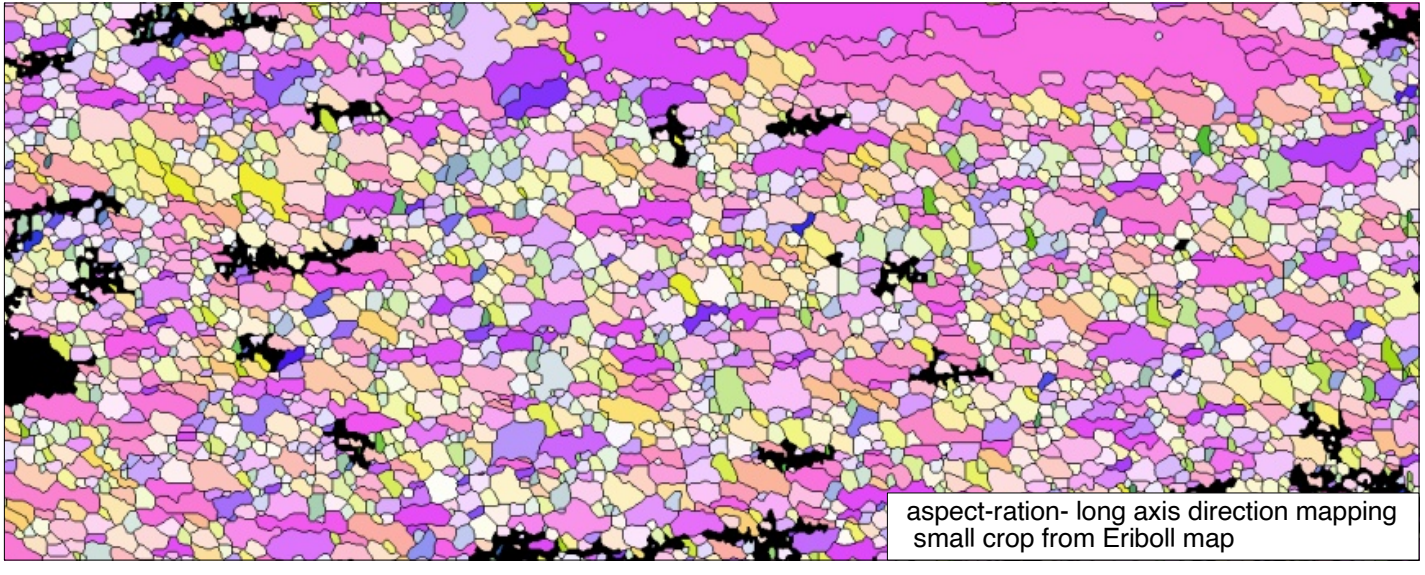
Example 2: Eriboll quartzite mylonite

relation between texture and grain properties: long axis direction (ω)



ω [°]	18-36	36-54	54-72	75-90	90-108	108-126	126-144	144-162	162-180	180-18
n	54617	22368	7586	3092	1902	1890	3439	9314	31471	67205



aspect-ration- long axis direction mapping
small crop from Eriboll map

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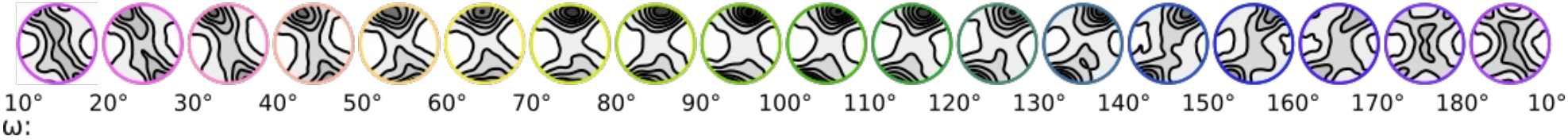
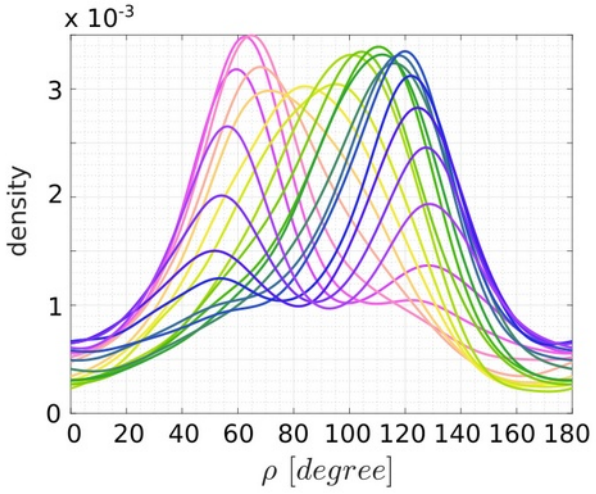
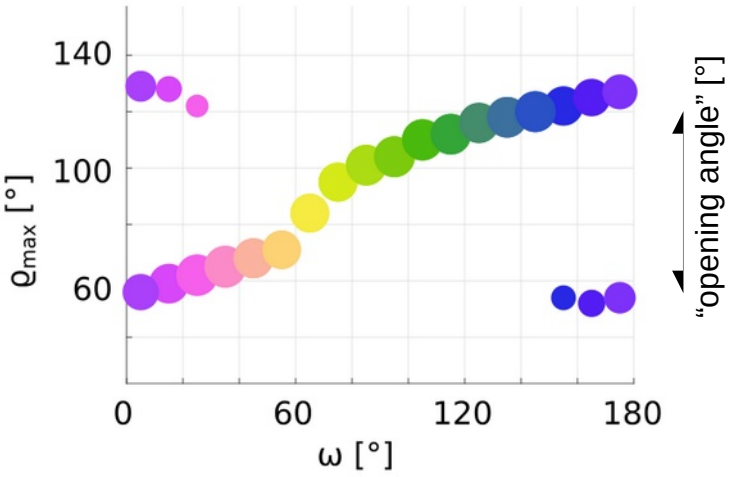


pole figure radial density



position pole figure radial density



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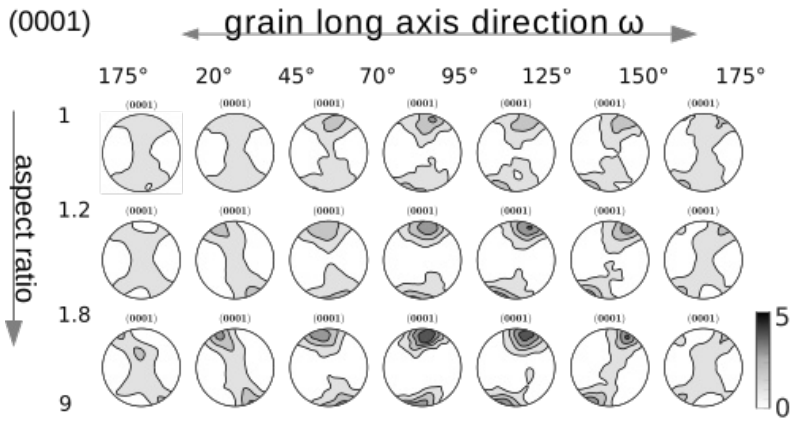
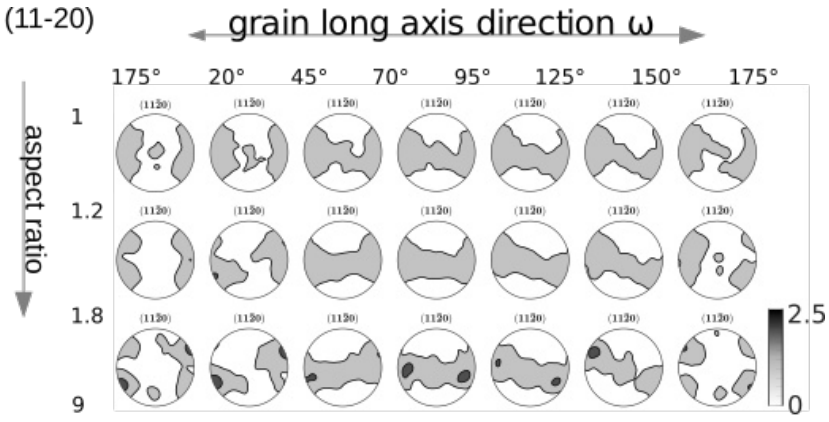
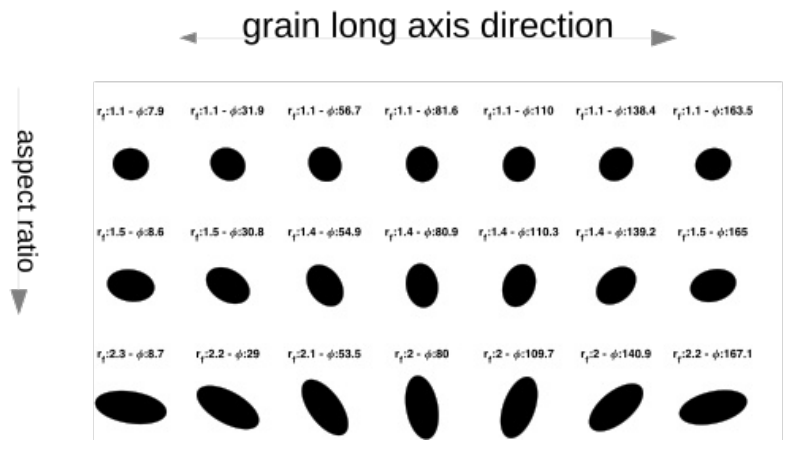




b) average grain aspect ratio and long axis direction for each class



relation of texture to <u>aspect ratio and grain long axis direction</u>:

- grains > 50 px
- odfs for each class estimated using KLCV
- grain size ignored (1 orientation for each grain)

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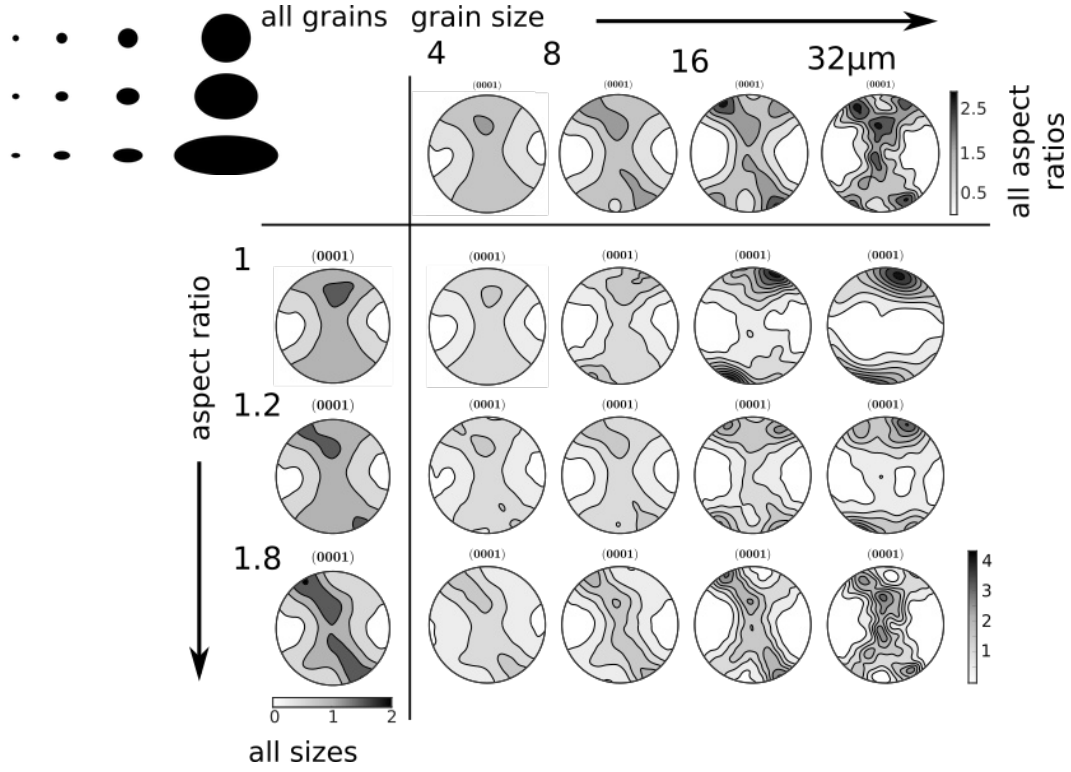
Example 2: Eriboll quartzite mylonite

relation between texture and grain properties: grain size dependency



- smallest grain size – weakest texture
- porphyroclasts – CPO of grains in “hard” orientation (low aspect ratio) clearly different from CPO of deforming grains (high aspect ratio)

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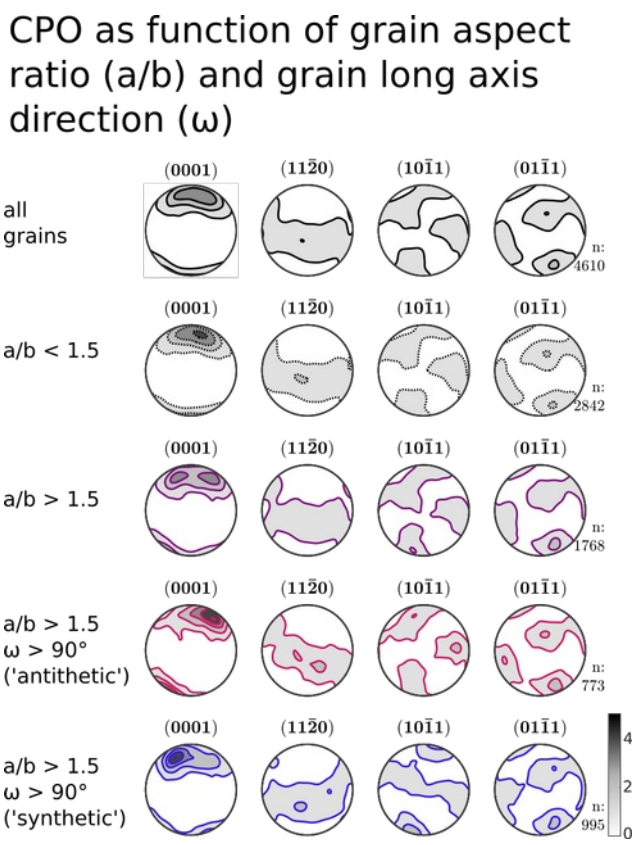
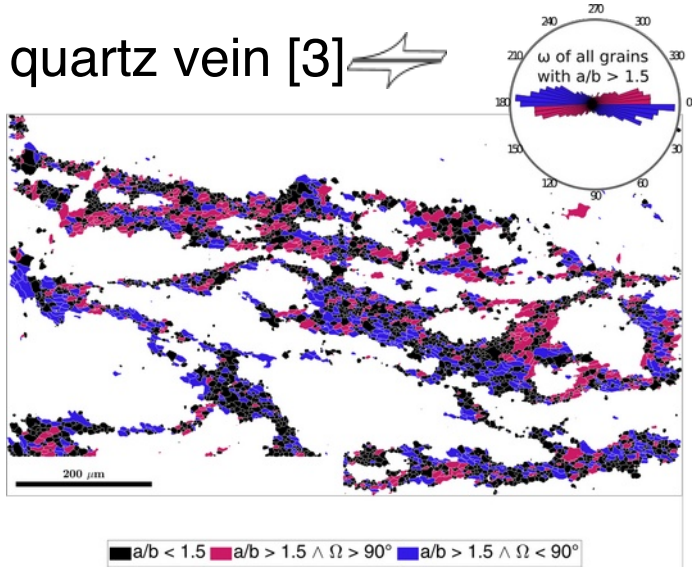
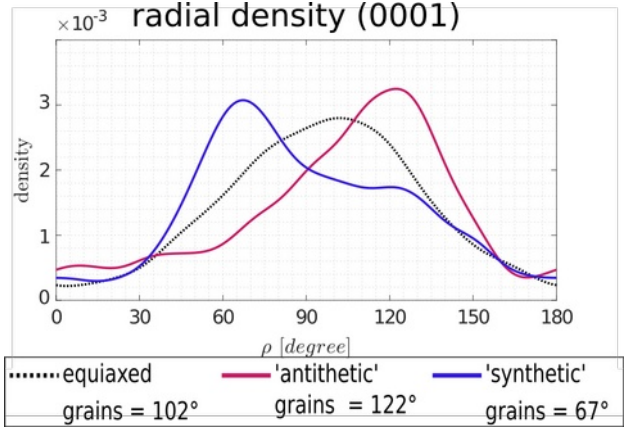
Example 3: deformed Tonale line quartz vein [3]







- bulging recrystallization
- low axial ratio grains appear with (0001) ll inferred shortening direction*
- grains with higher aspect ratio form two groups which can be separated into to unimodal (0001) components based on their grain long axis direction
- interpretation: syn- and antithetical slip (strain partitioning)

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1) Summary

- (0001) pole figures can be decomposed into girdles and unimodal components
- components are best separated by best fit-ellipse parameters (aspect ratio and long axis direction)

3) Take-home message

- finite CPO reflect combinations of mutually acting deformation and recrystallization processes
- because all components are found in single samples, any temperature relation (a.k.a. the „opening angle thermometer“) can be at the most of indirect nature and can be expected to arbitrary results

2) Aspect ratio and long axis direction of grains in a deforming aggregate depend on the mutual contributions of:

- deformation of a grain
  - ➔ grain follows a strain trajectory
- partition of bulk flow by individual grains
  - ➔ syn- and antithetical domains/grains
- recrystallization processes
  - ➔ e.g. decreased aspect ratios, deviation from strain trajectory [4]
- directed growth
  - ➔ grain shapes can be unrelated to finite deformation

need more explanation ?
please ask the authors

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References:

[1] Heilbronner, R., Tullis J., 2006 https://doi.org/10.1029/2005JB004194
[2] Kilian, R., Heilbronner, R.,2017 https://doi.org/10.5194/se-8-1095-2017
[3] Stipp, M. and Kunze, K., 2008 https://doi.org/10.1016/j.tecto.2007.11.041
[4] Schmid, S., Panozzo, R., Bauers, S., 1987 https://doi.org/10.1016/0191-8141(87)90157-X