QUANTIFICATION OF DISLOCATION CREEP MICROSTRUCTURES IN QUARTZ: COMPARISON OF NATURAL AND EXPERIMENTAL DEFORMATION

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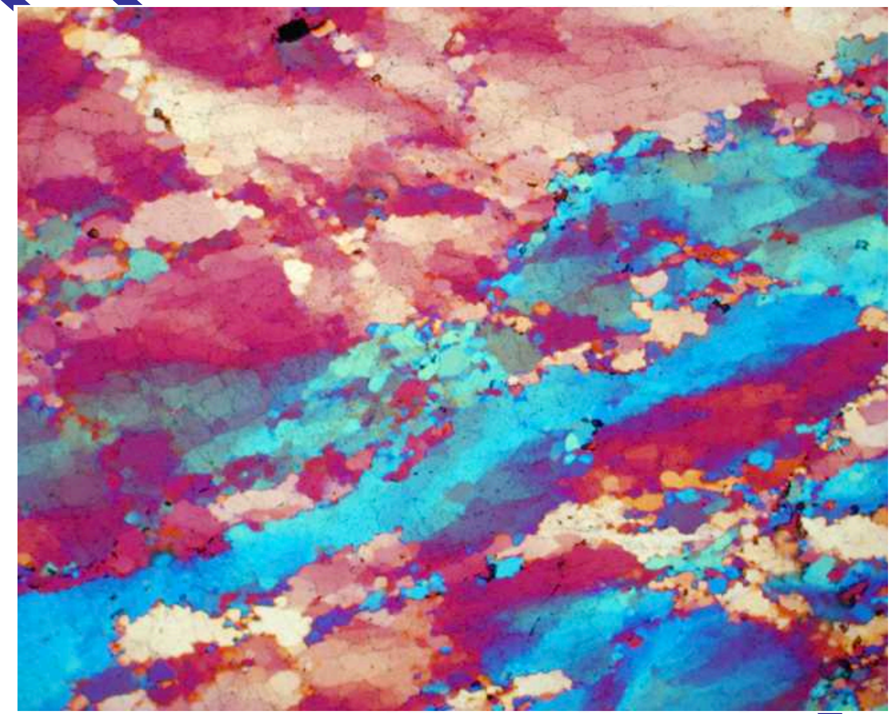
DEFORMATION

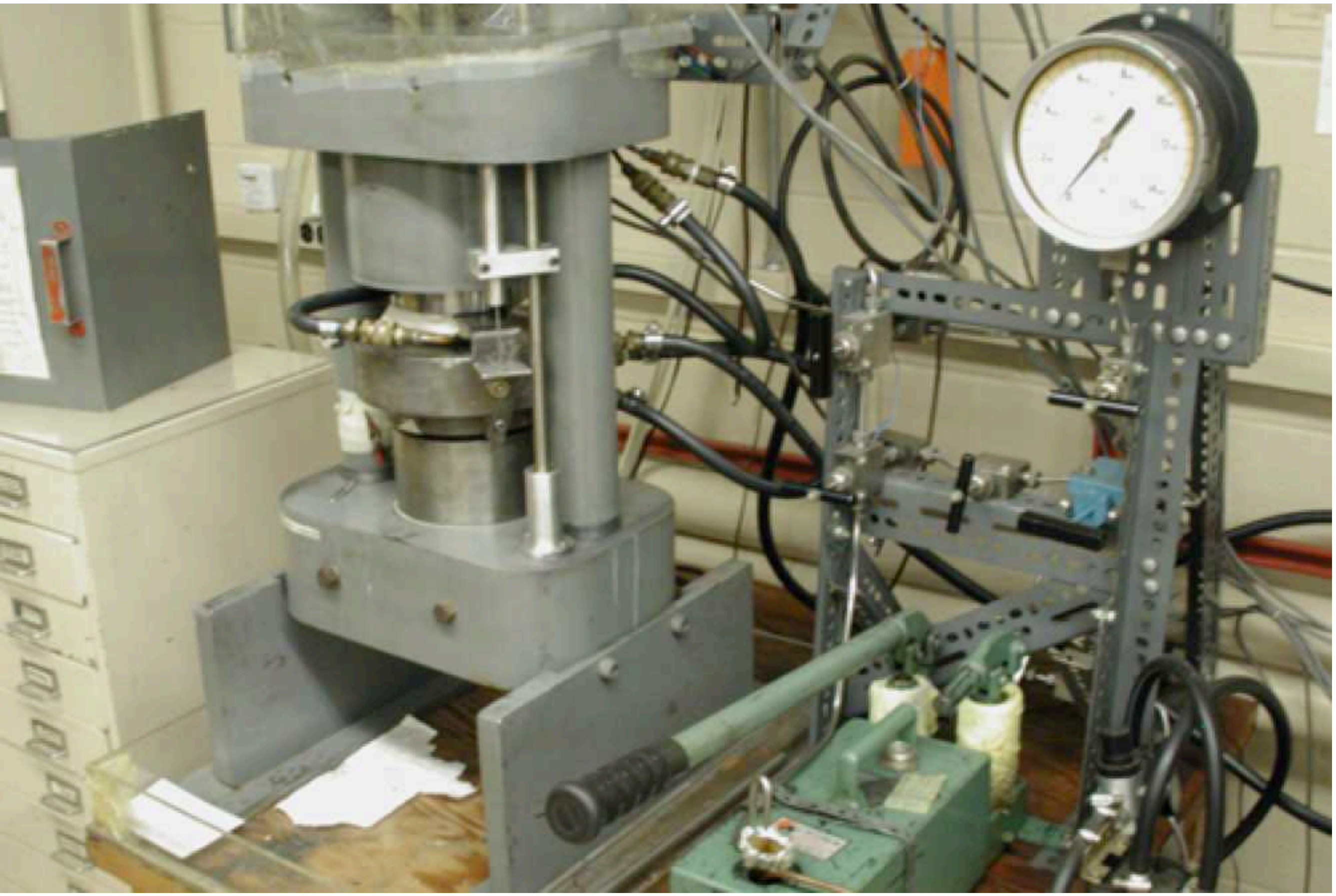
EXPERIMENT

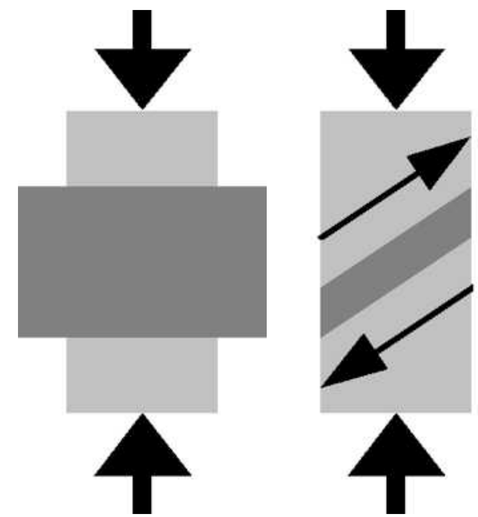


NATURE

"microstructures are the link between nature and experiment"

EXPERIMENTAL ROCK DEFORMATION



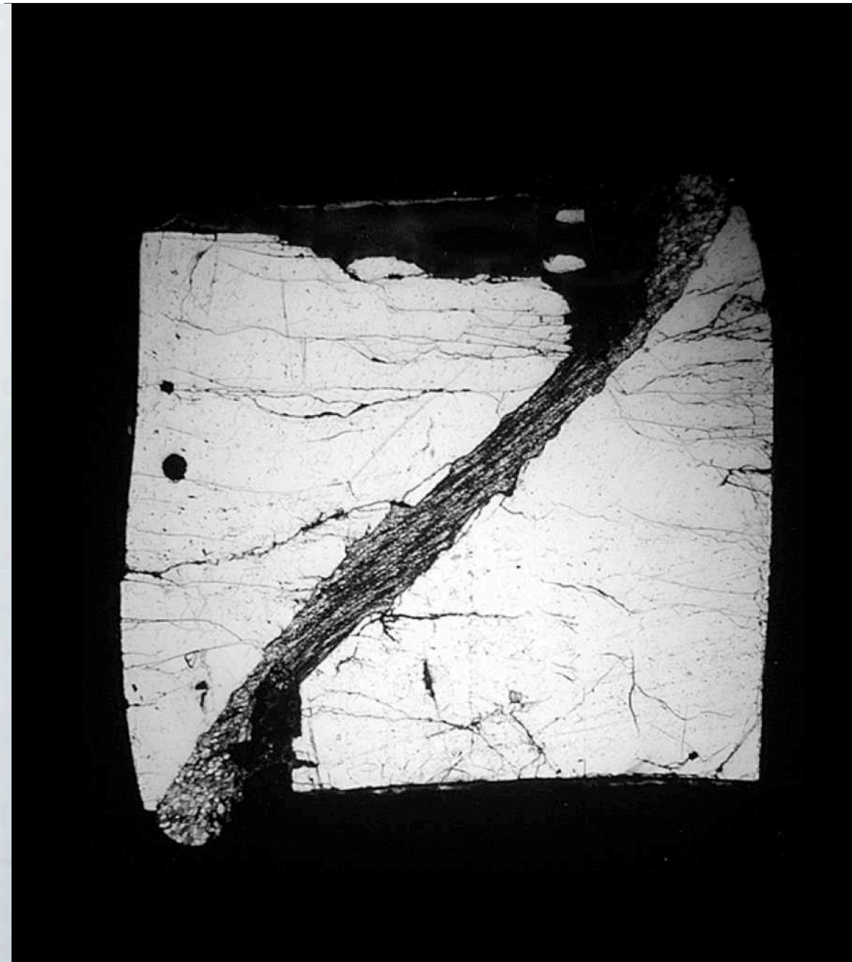


Griggs apparatus, solid medium

axial shearing

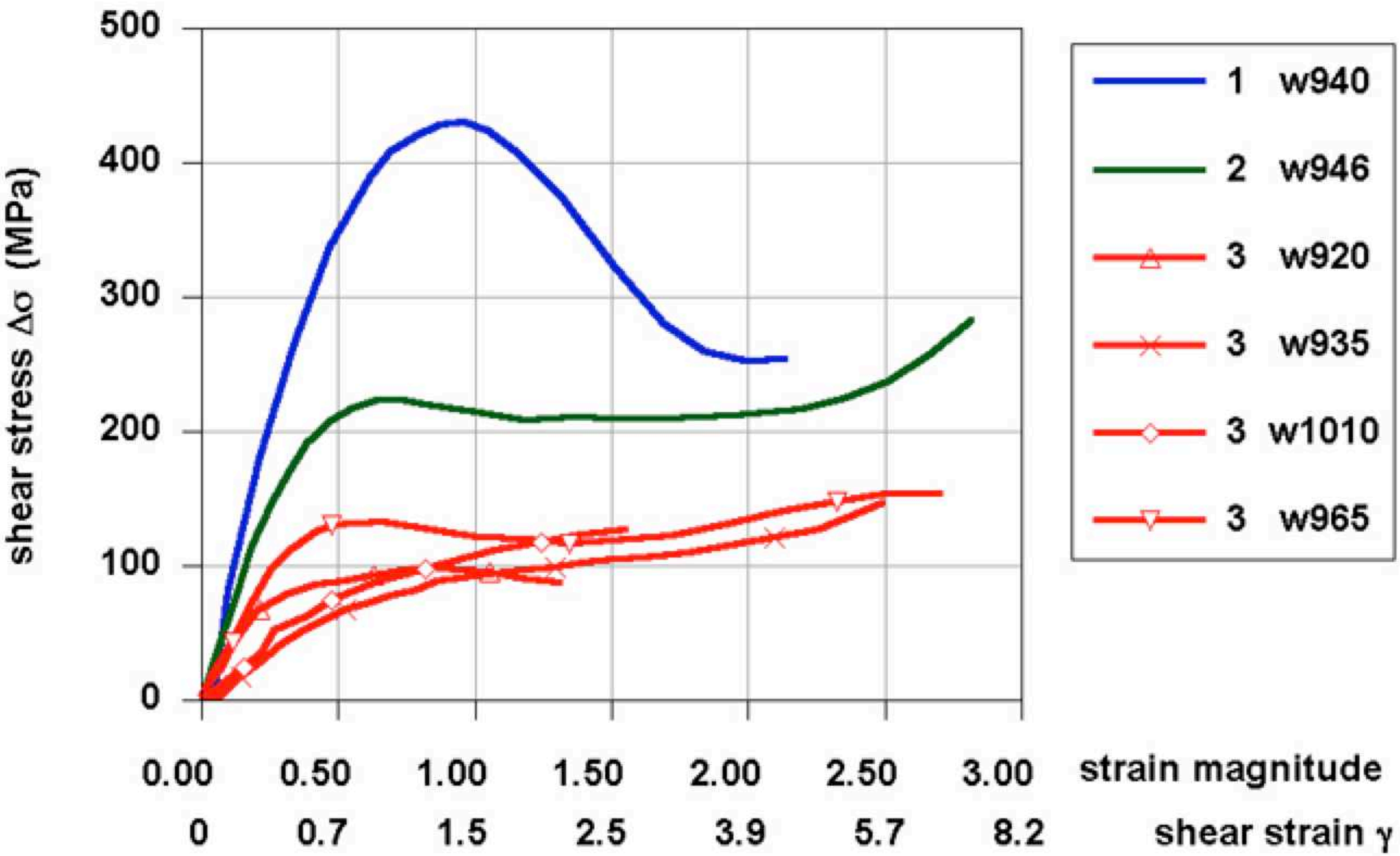
SAMPLE ASSEMBLY

Brazil quartz forcing blocks



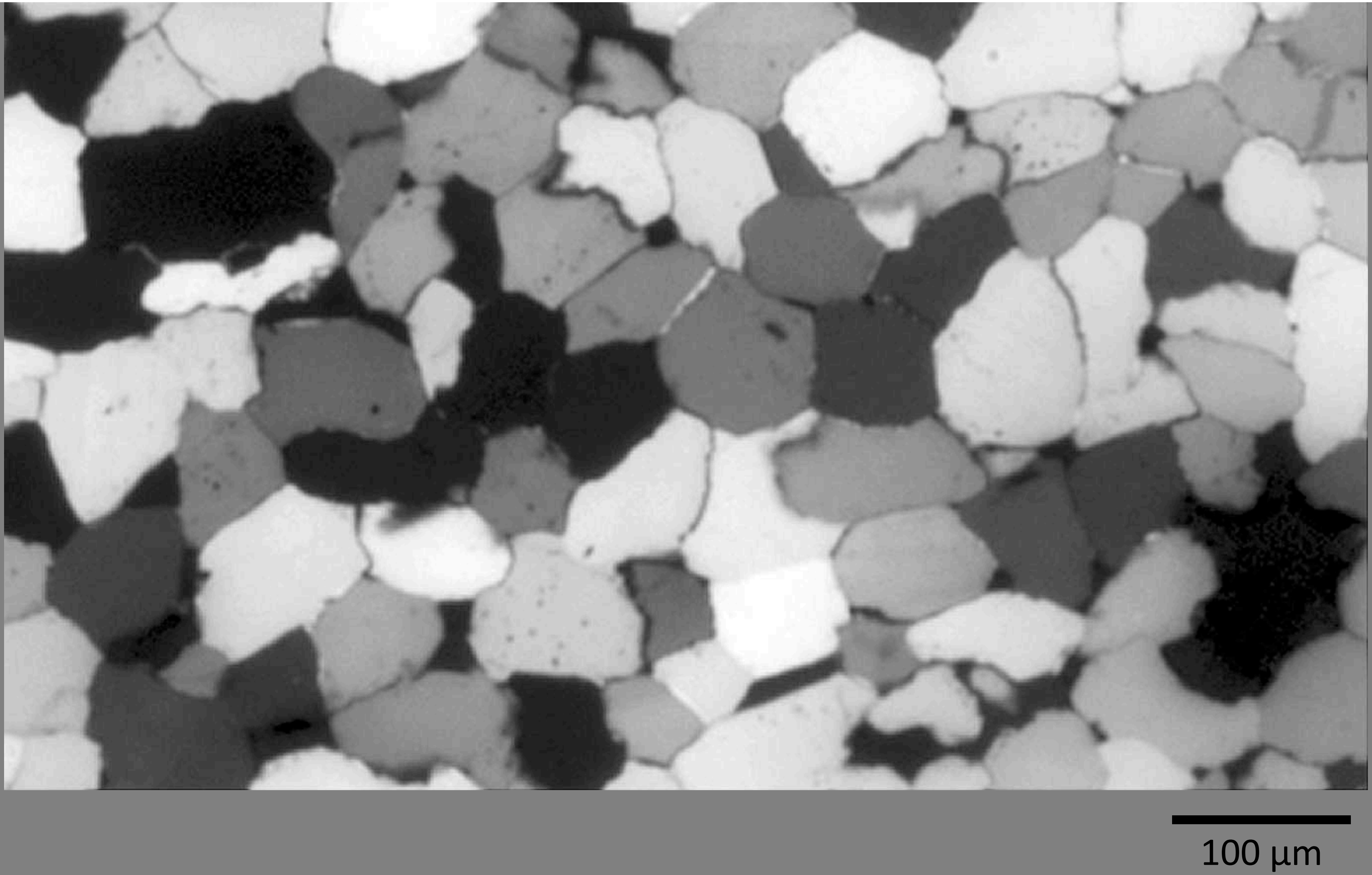
Black Hills Quartzite

MECHANICAL DATA OF SHEARING EXPERIMENTS

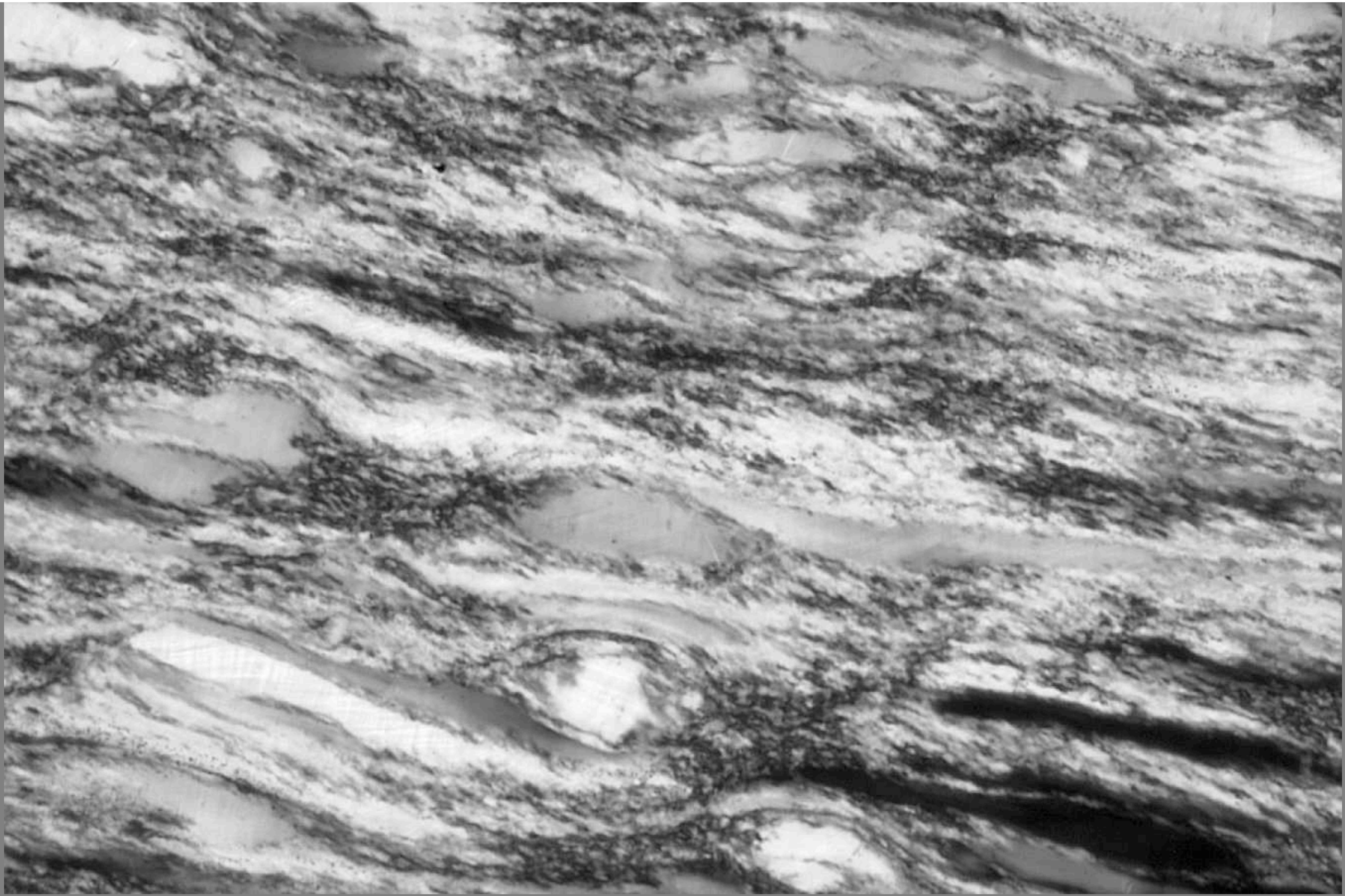


shearing experiments: Black Hills quartzite, dislocations creep

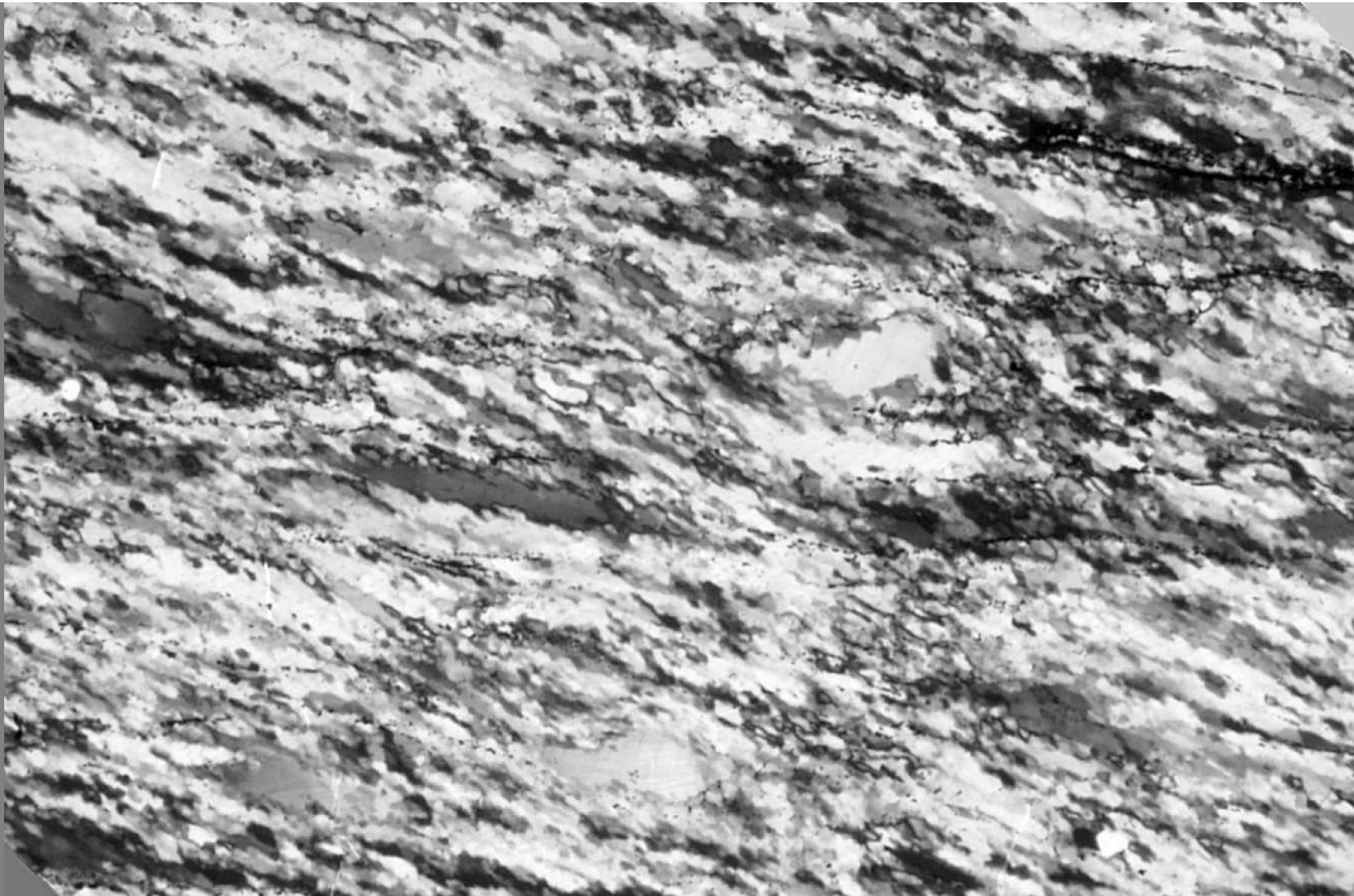
UNDEFFORMED BLACK HILLS QUARTZITE



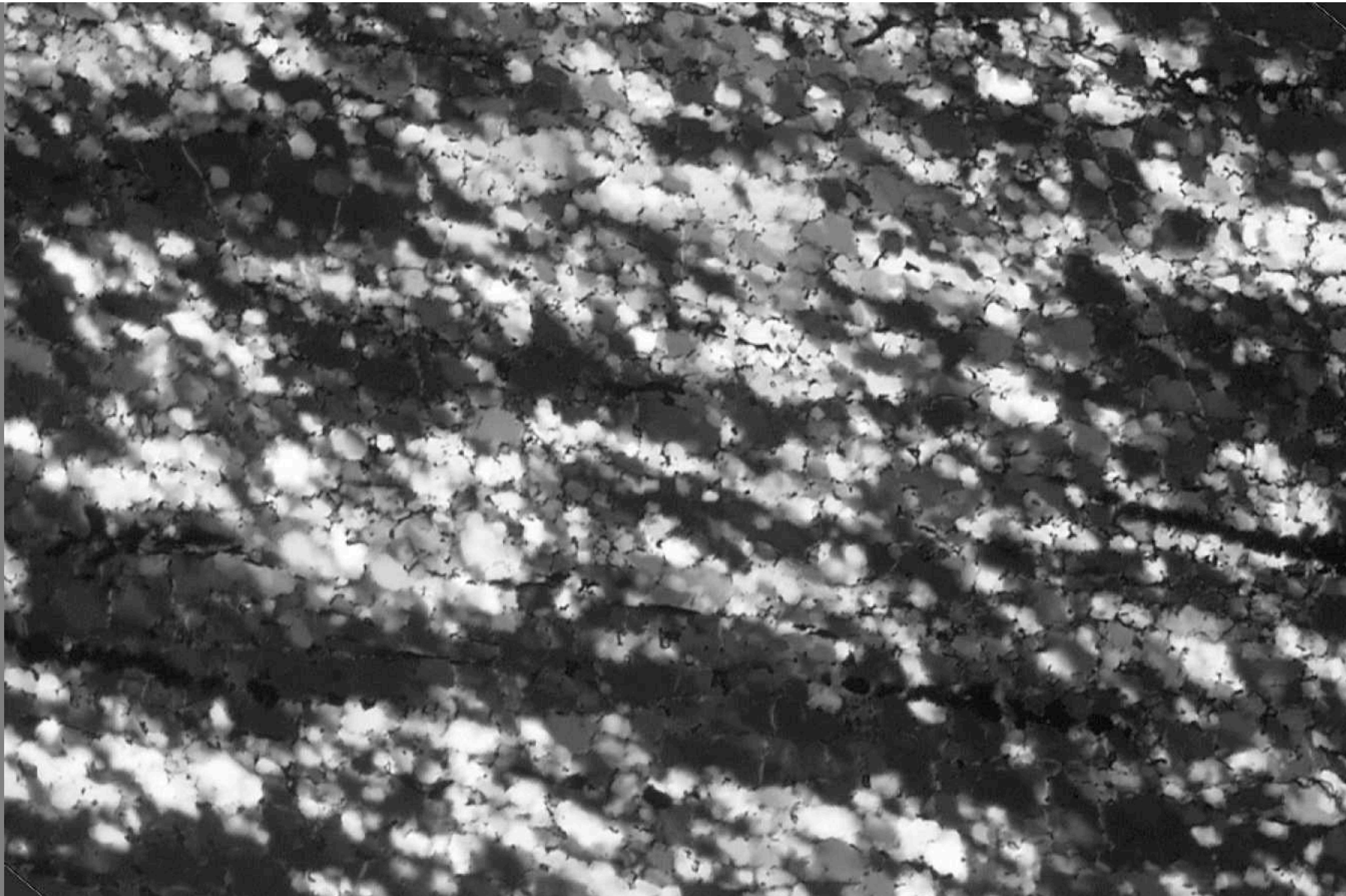
REGIME 1



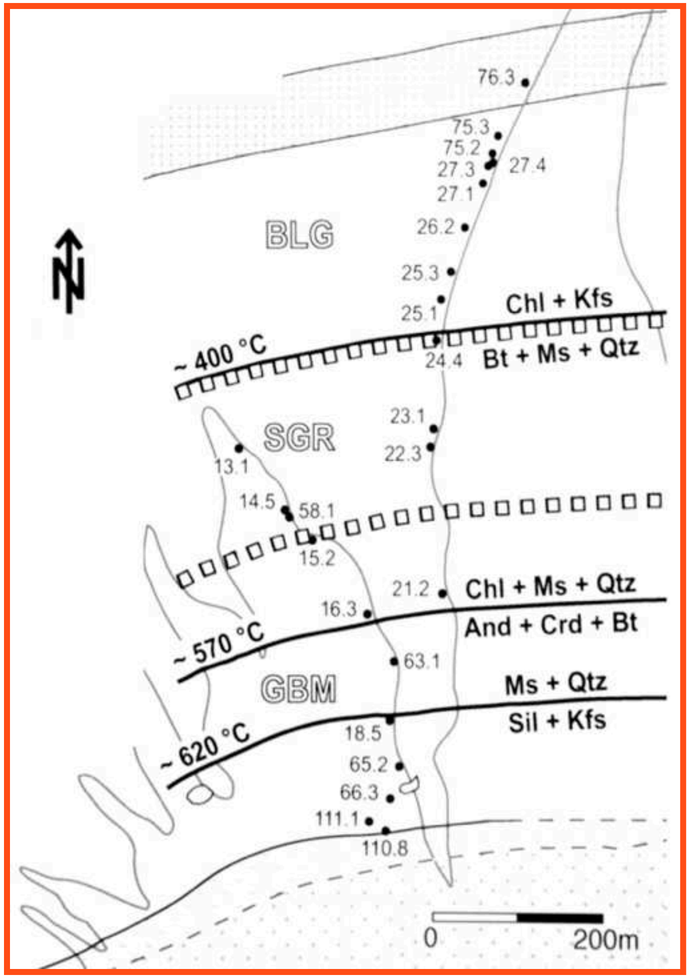
REGIME 2



REGIME 3

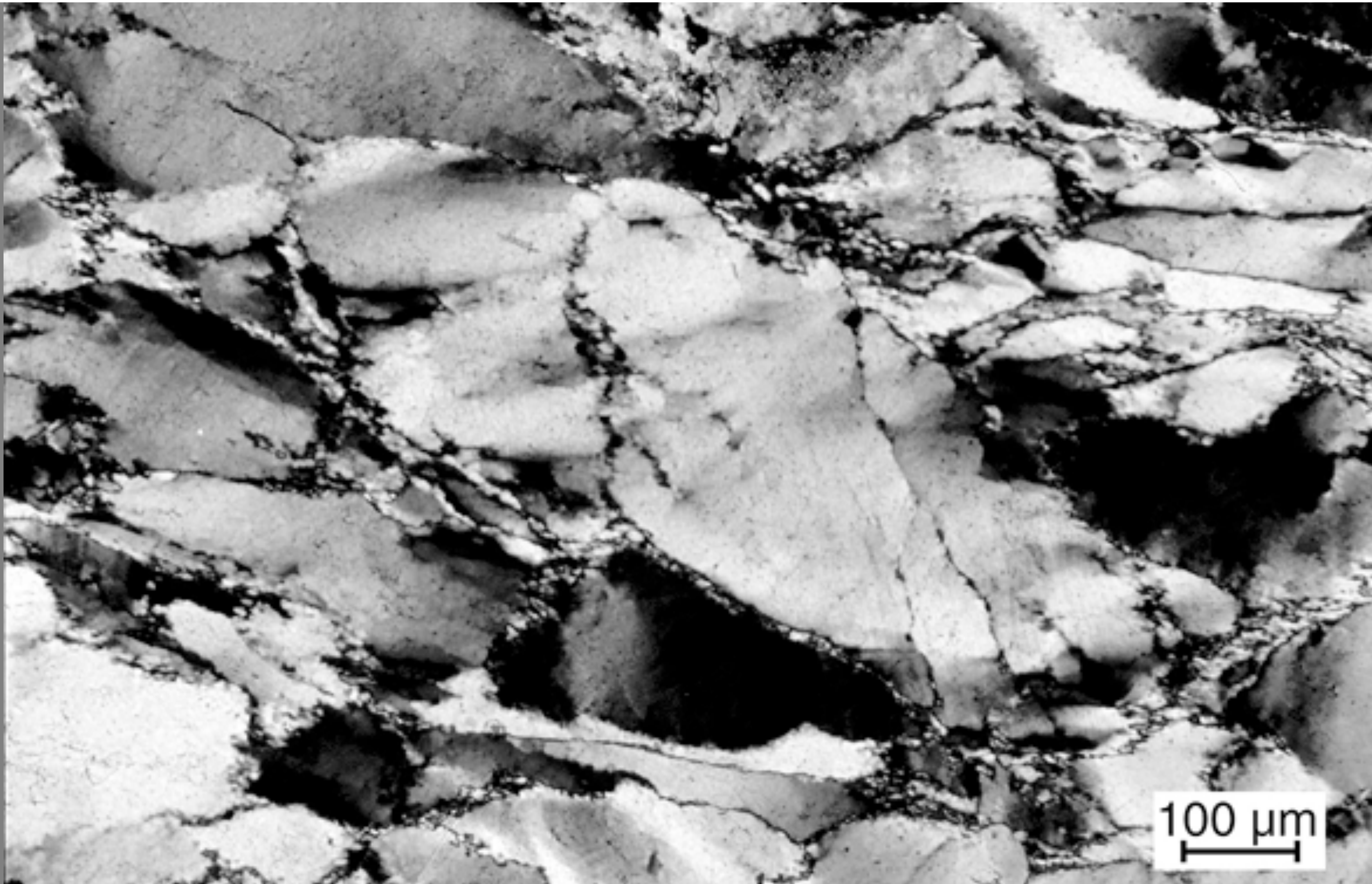


NATURALLY DEFORMED QUARTZ VEINS

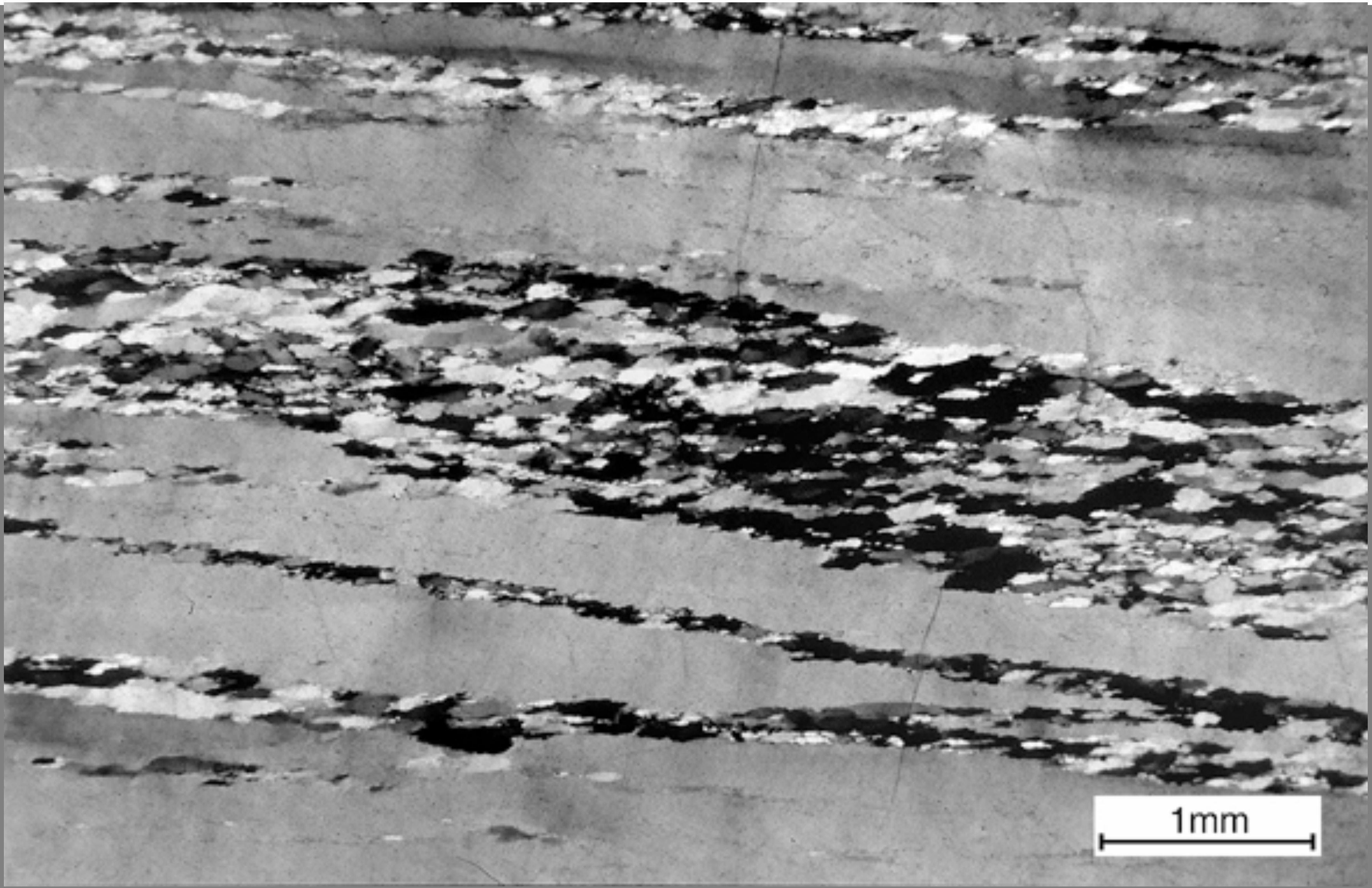


Stavel profile, Tonale Line, Northern Iltaly

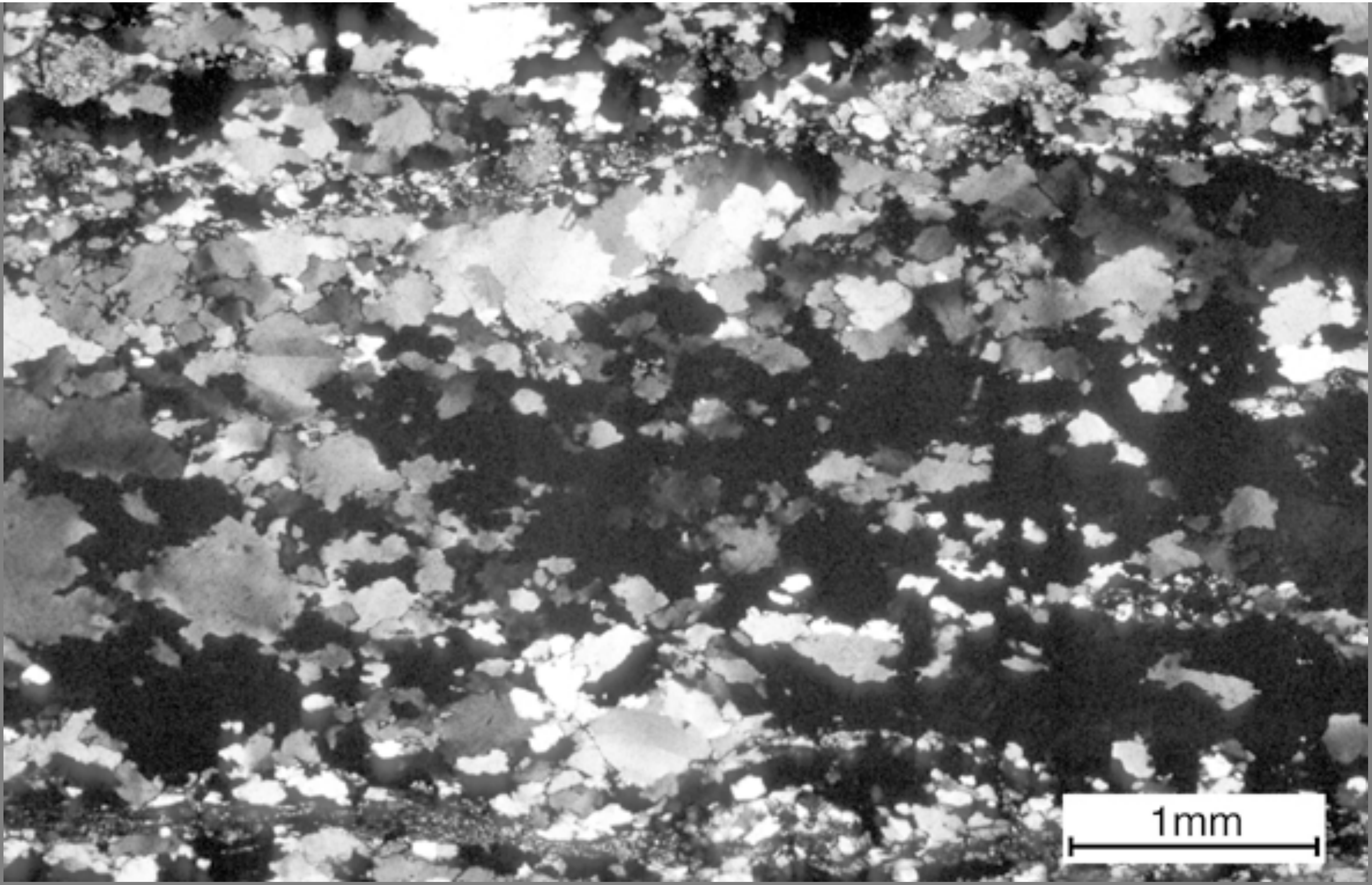
BULGING



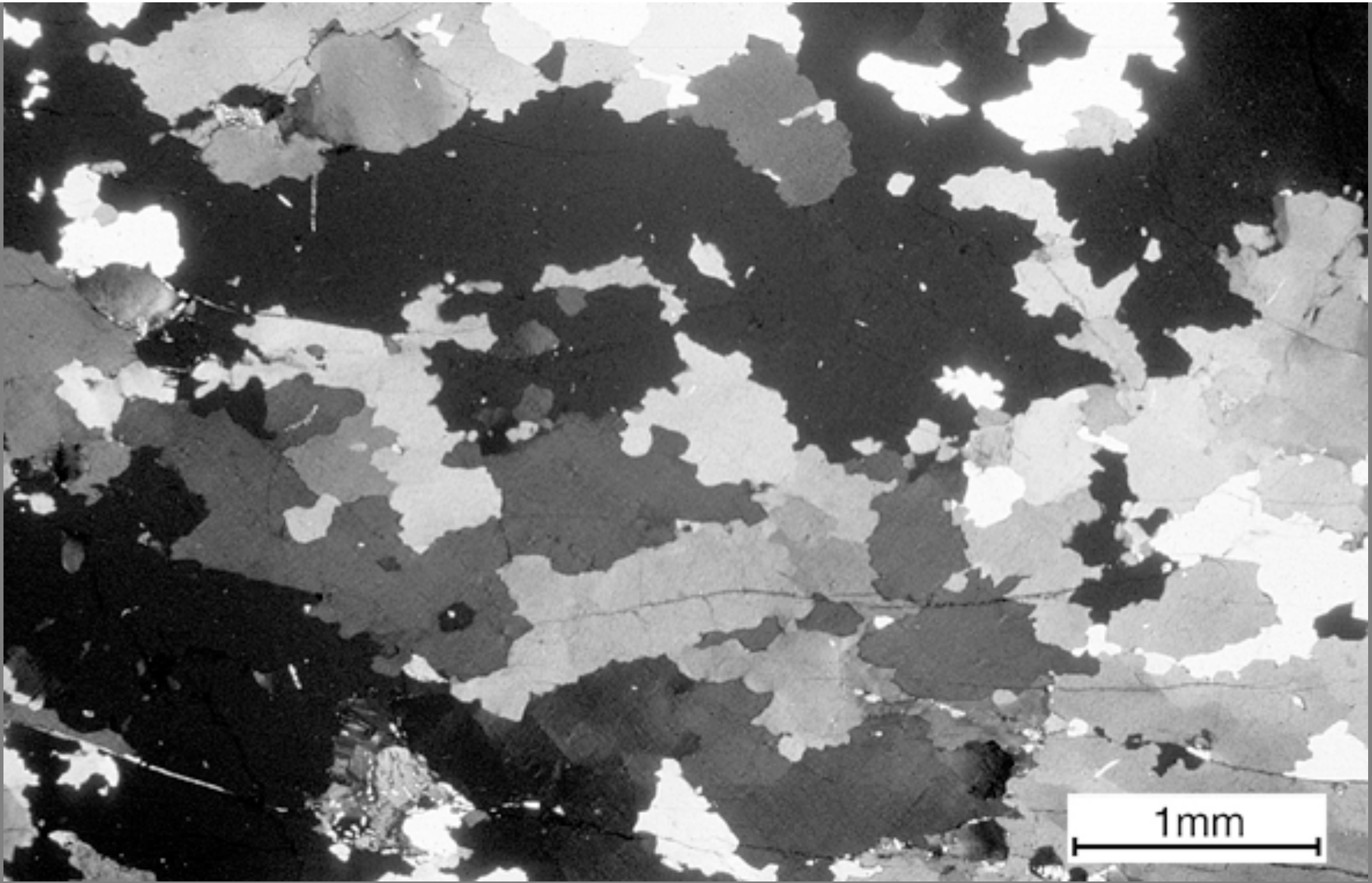
SUBGRAIN ROTATION



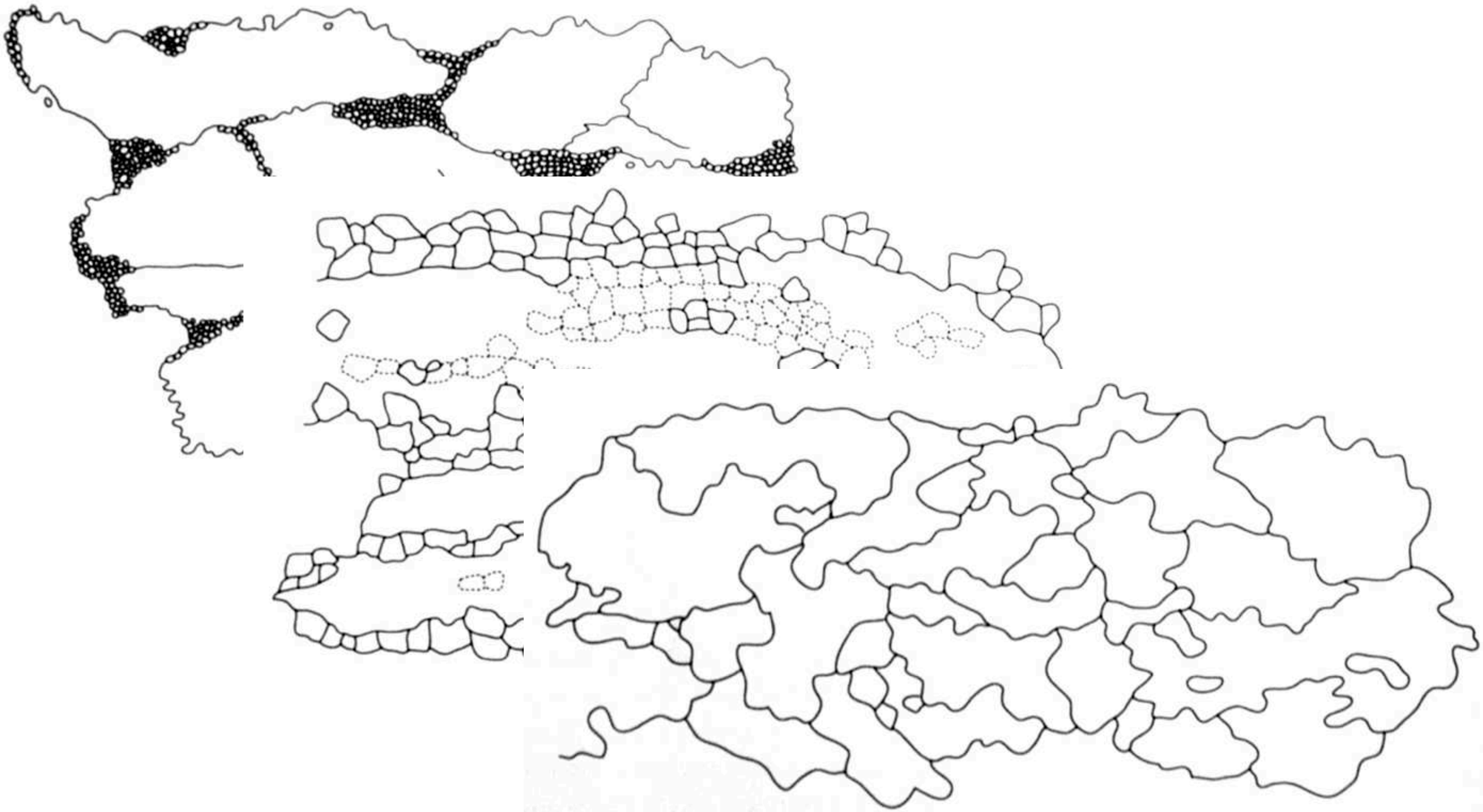
GRAIN BOUNDARY MIGRATION I



GRAIN BOUNDARY MIGRATION II

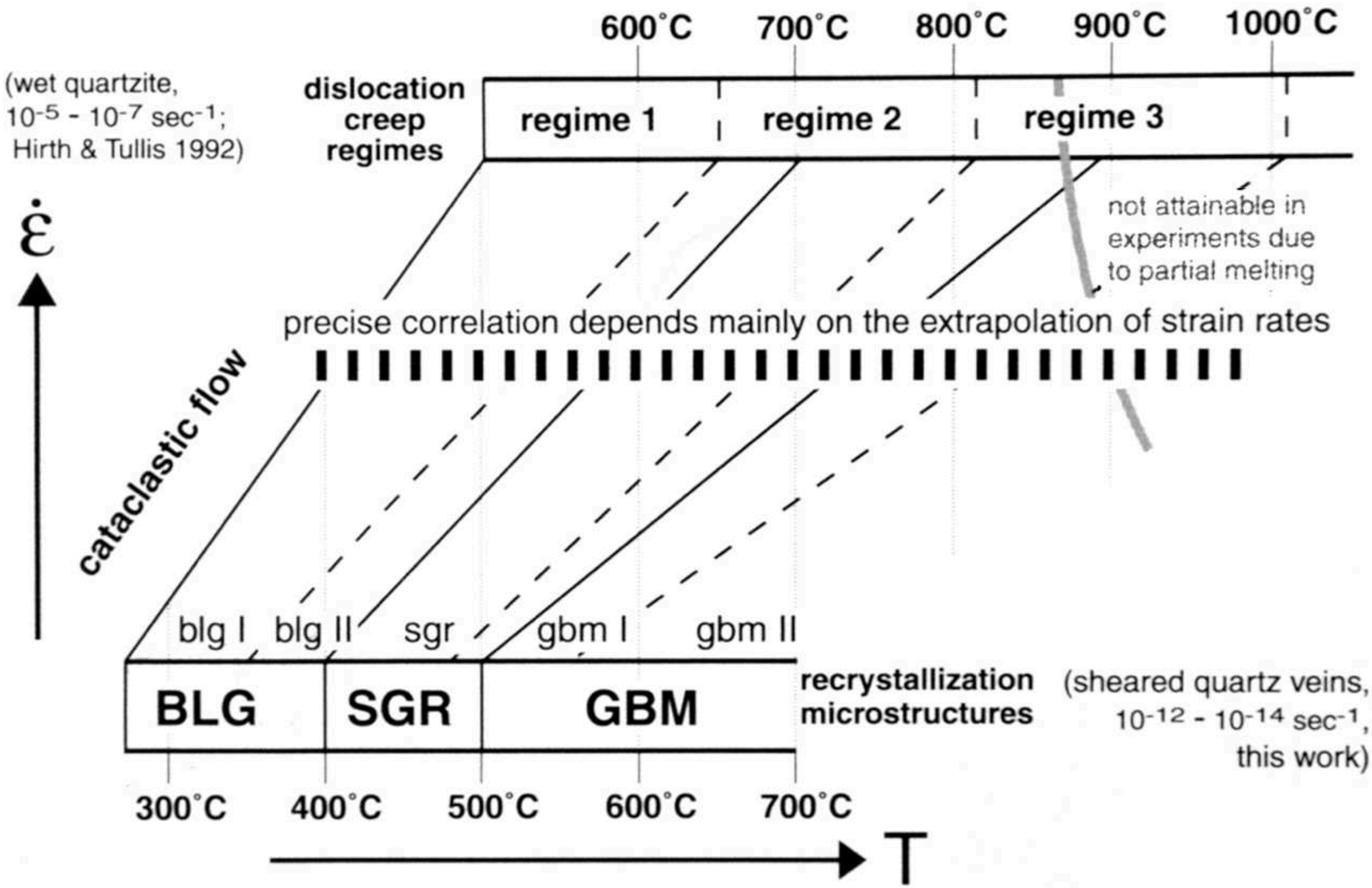


SCHEMATIC OF THREE REGIMES

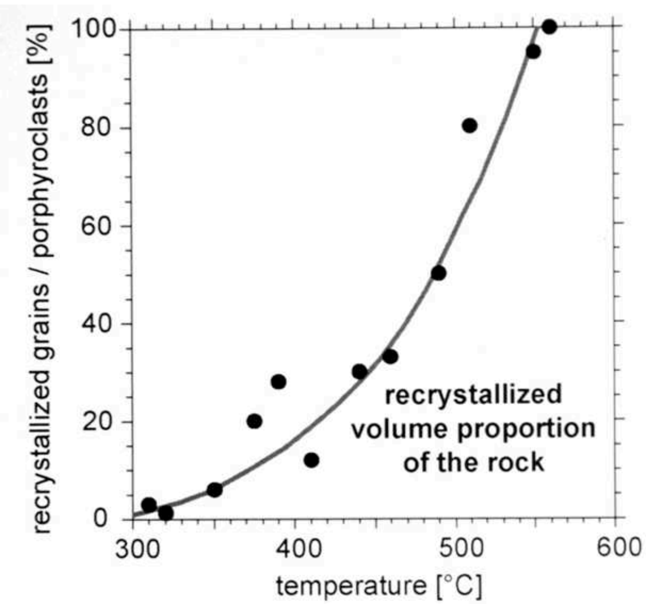


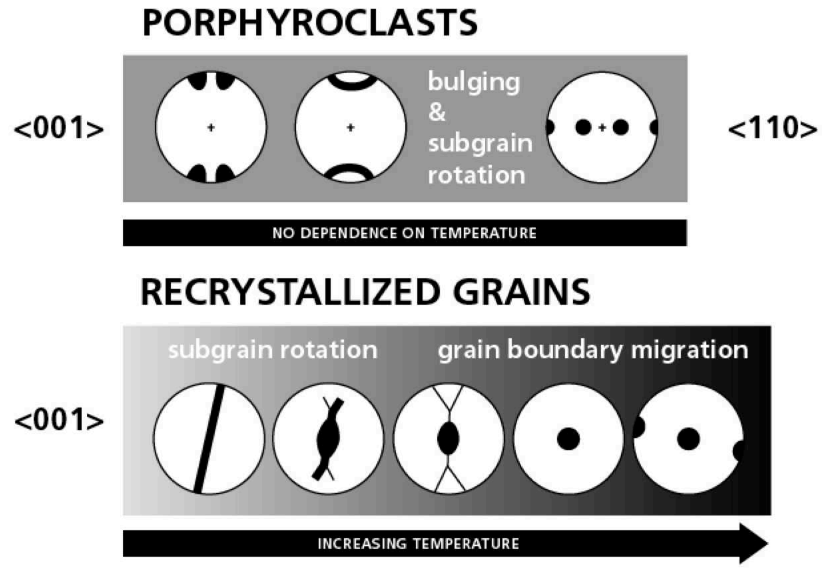
lowT GBM dominated - SGR dominated - highT GBM dominated

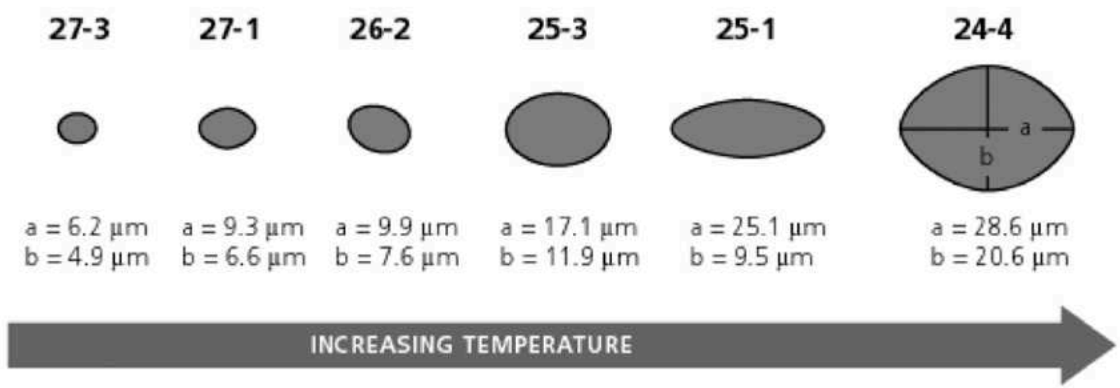
CORRELATION NATURE - EXPERIMENT



DIAGNOSTIC PROPERTIES

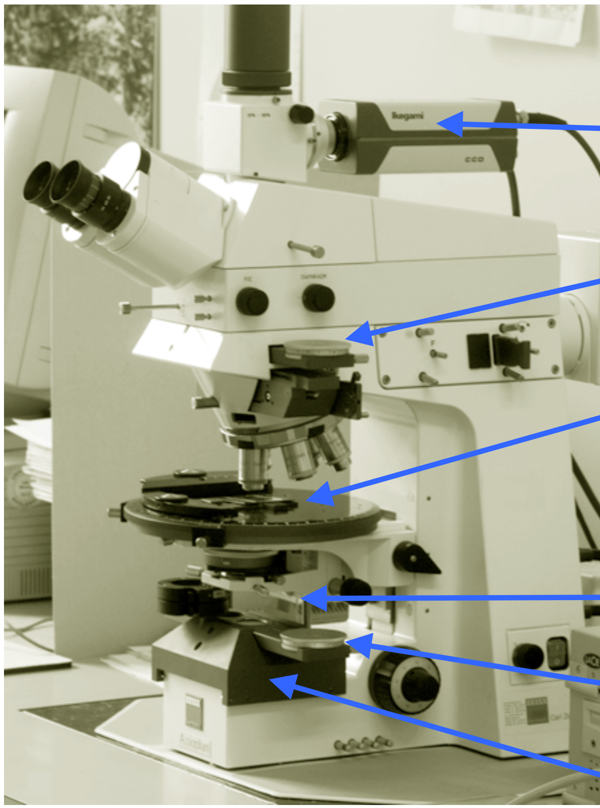






vol% recrystallized grain shape CPO development

COMPUTER-INTEGRATED POLARIZATION MICROSCOPY



Infrared-sensitive digital camera

Infrared-sensitive video camera

Rotating polarizer (360°)

Microscope table with tilt stage

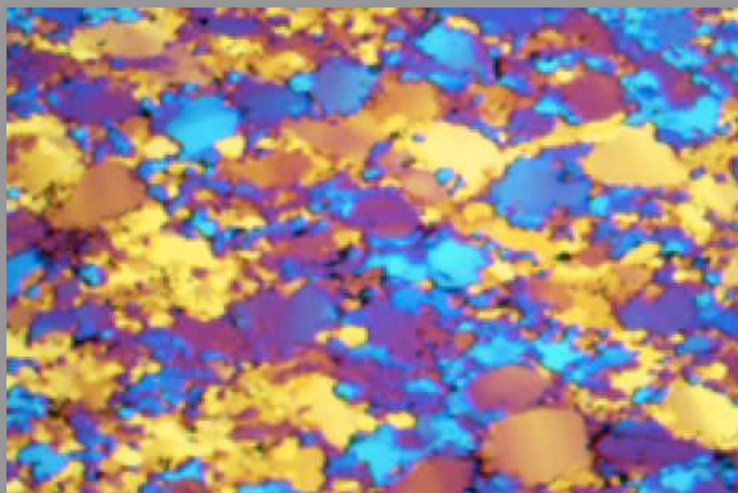
Incandescent light source

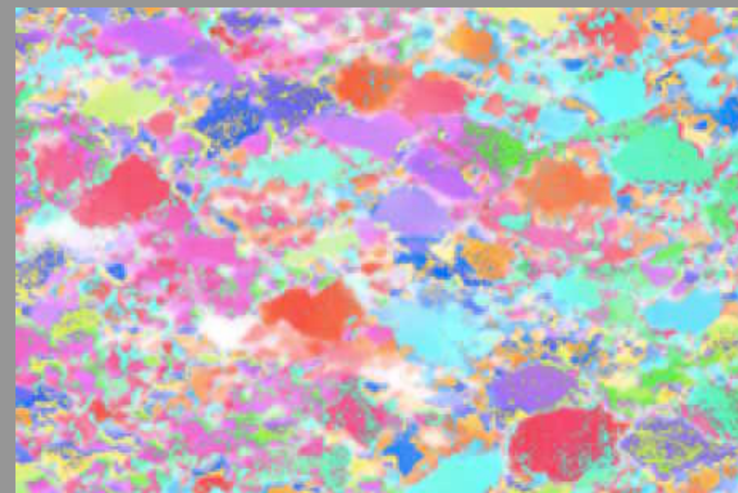
Condensor with $\lambda/4$ plate

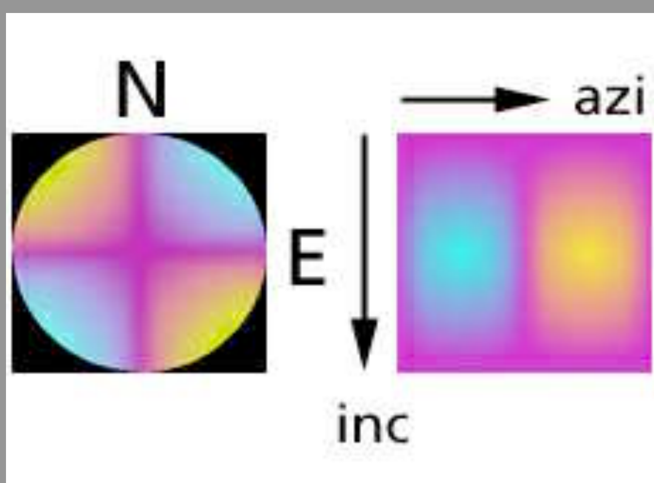
Rotating polarizer & lambda plate (360°)

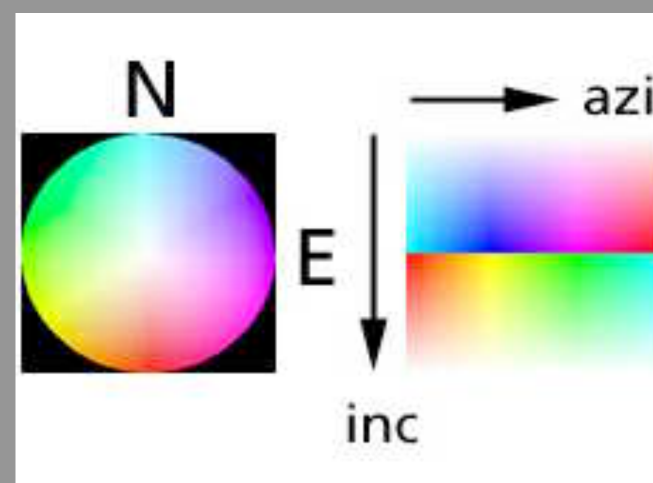
Holder for rotating polarizer and narrow-band interference filter (660, 700nm)

CIP = ORIENTATION MAPPING

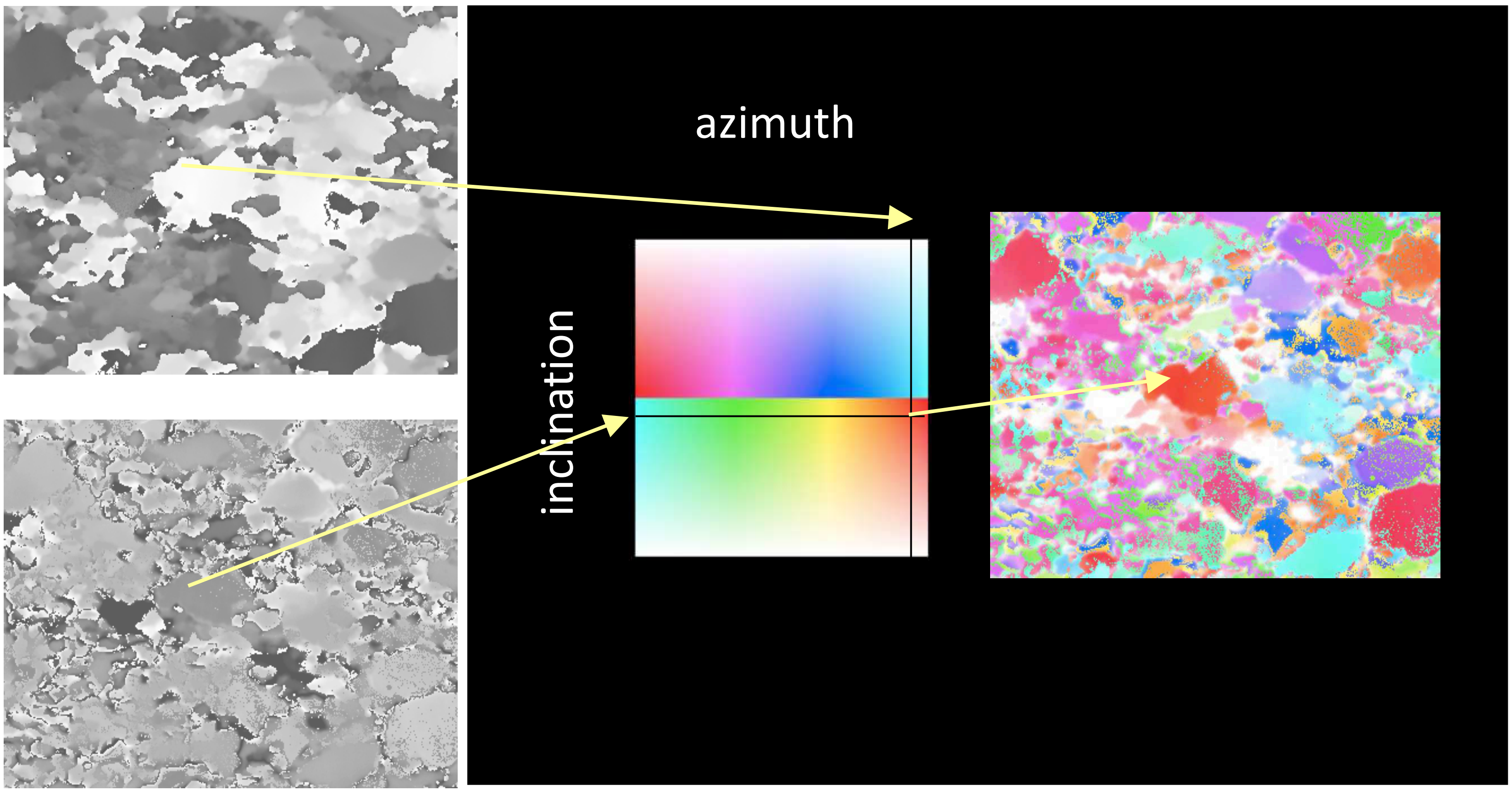








c-AXIS ORIENTATION IMAGE

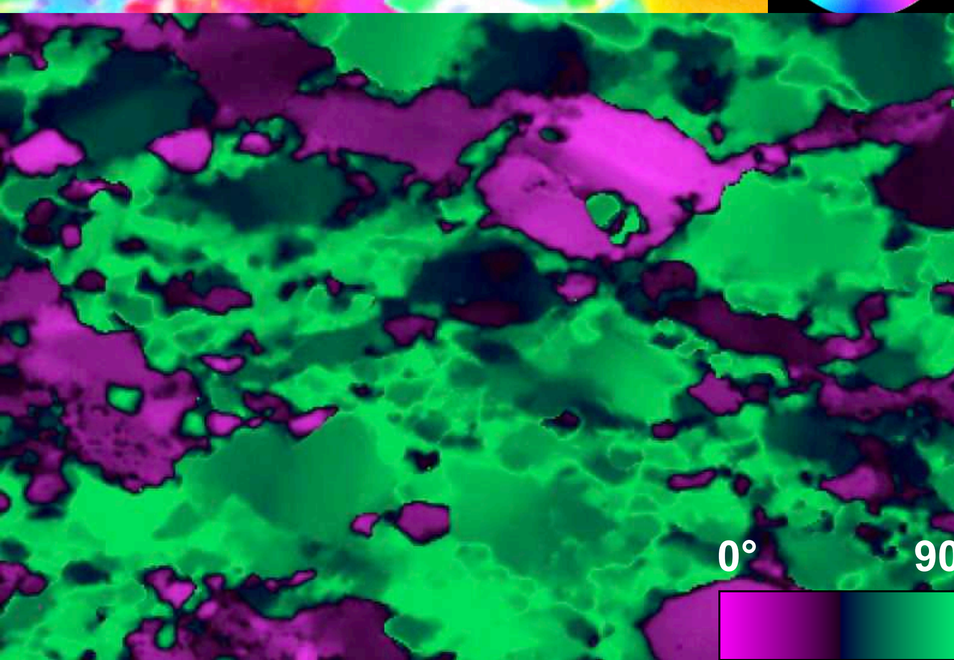


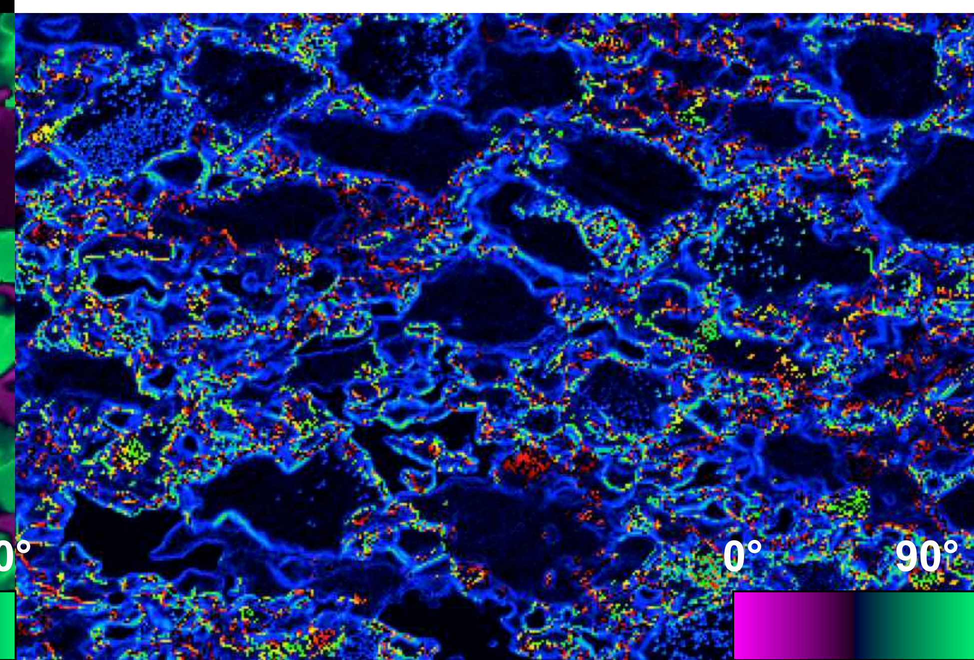
types of orientation images

1 c-axis orientation image

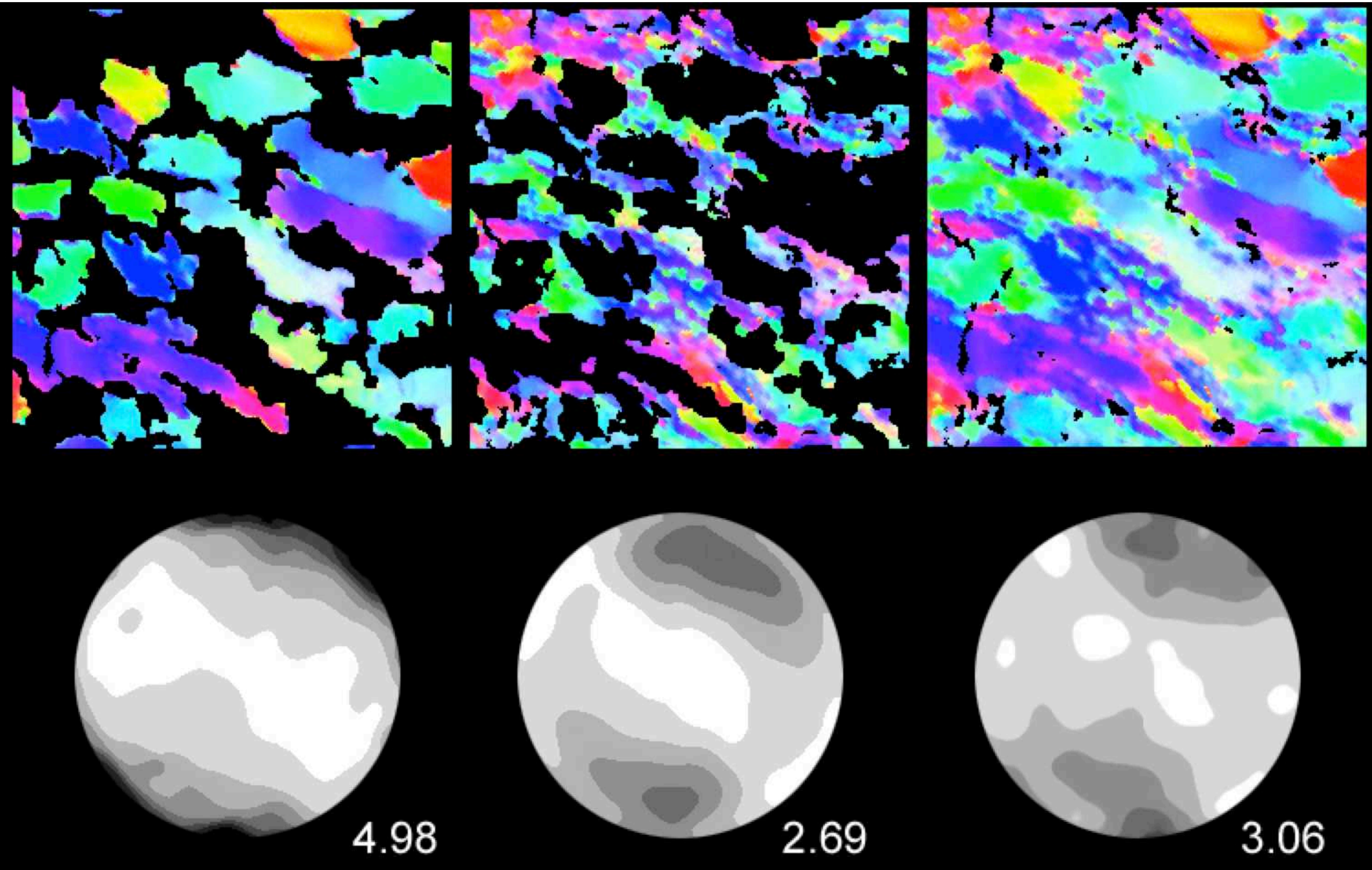
2 misorientation image

3 orientation gradient image

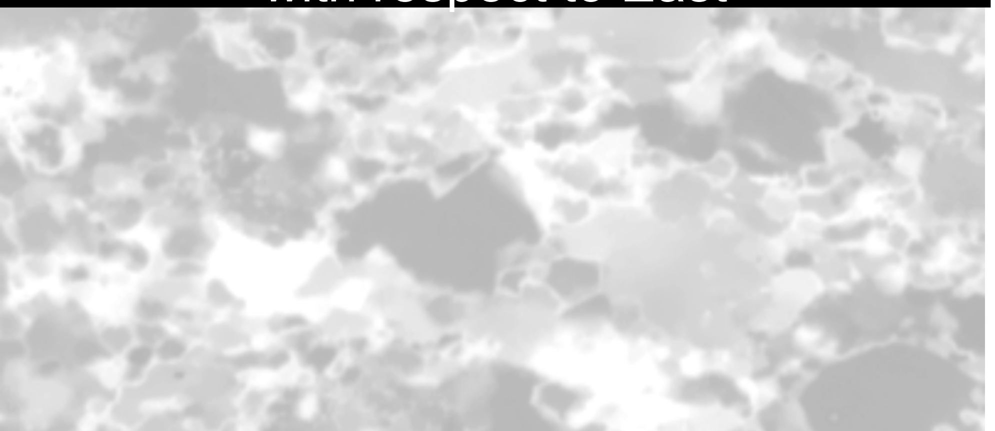




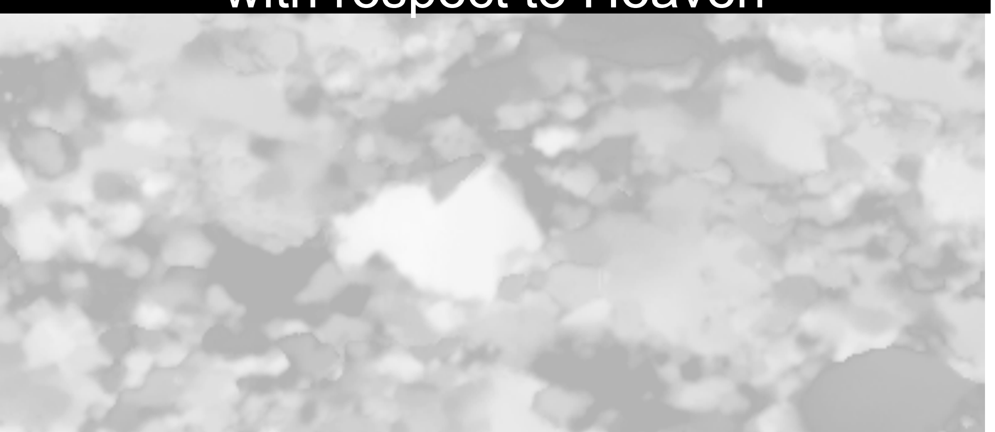
PARTIAL TEXTURES



with respect to East



with respect to Heaven

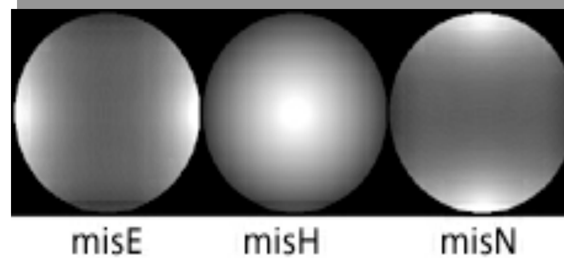


with respect to North

MISORIENTATION IMAGES

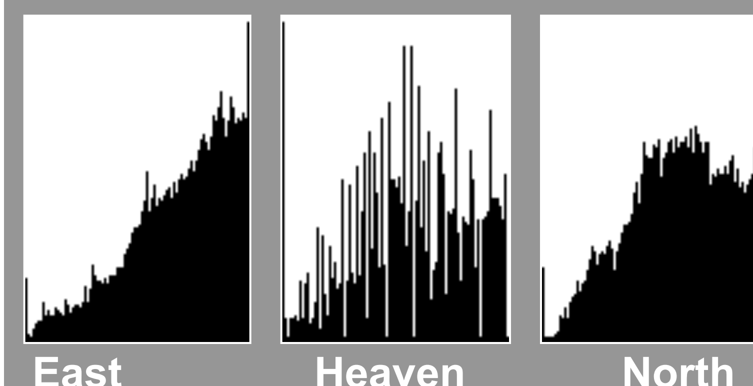
w/r to reference direction:

East, North, Heaven/Hell

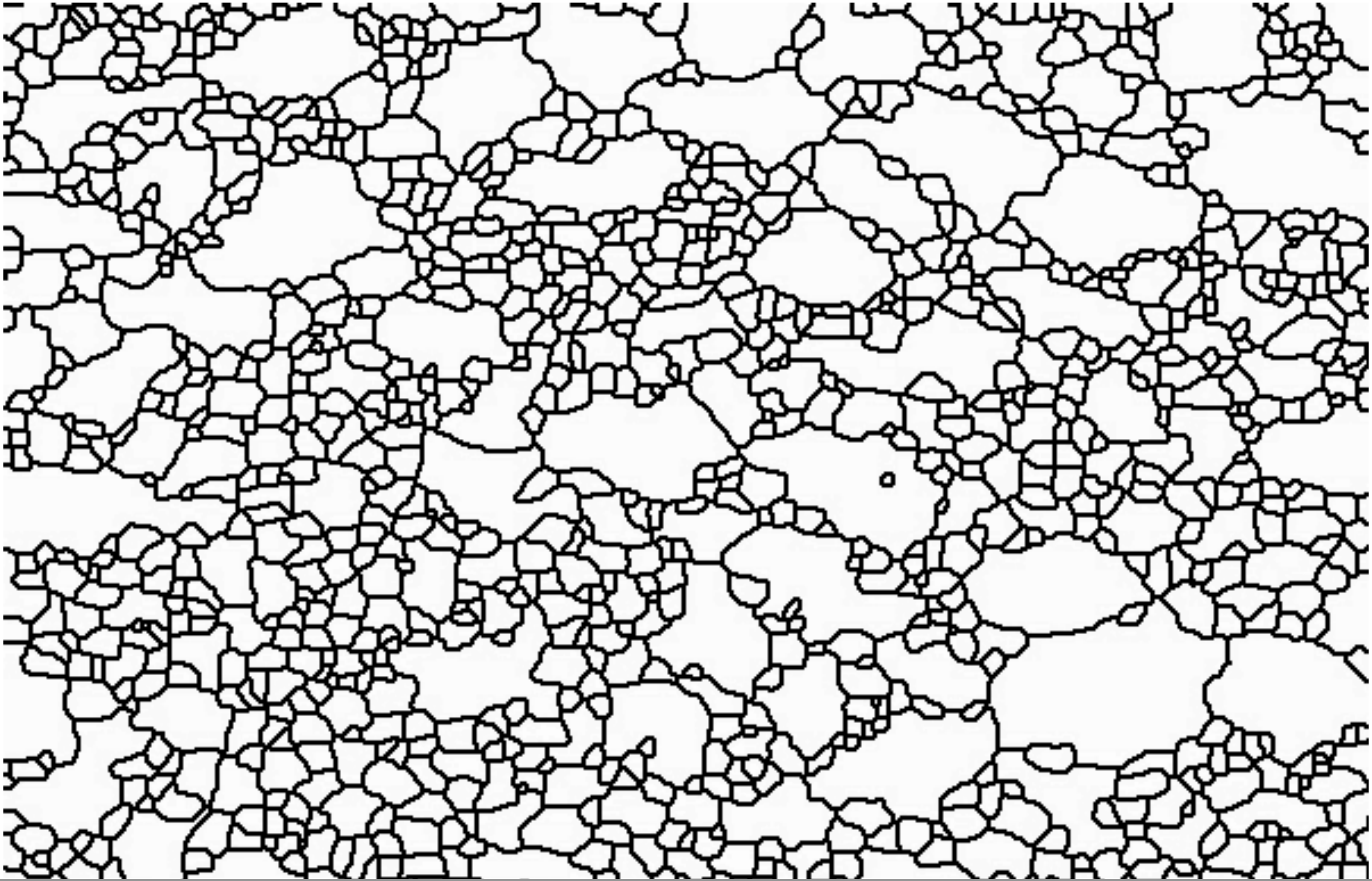


values from 0° to 90°

90 of 255 greyvalues



GRAIN BOUNDARY MAPPING

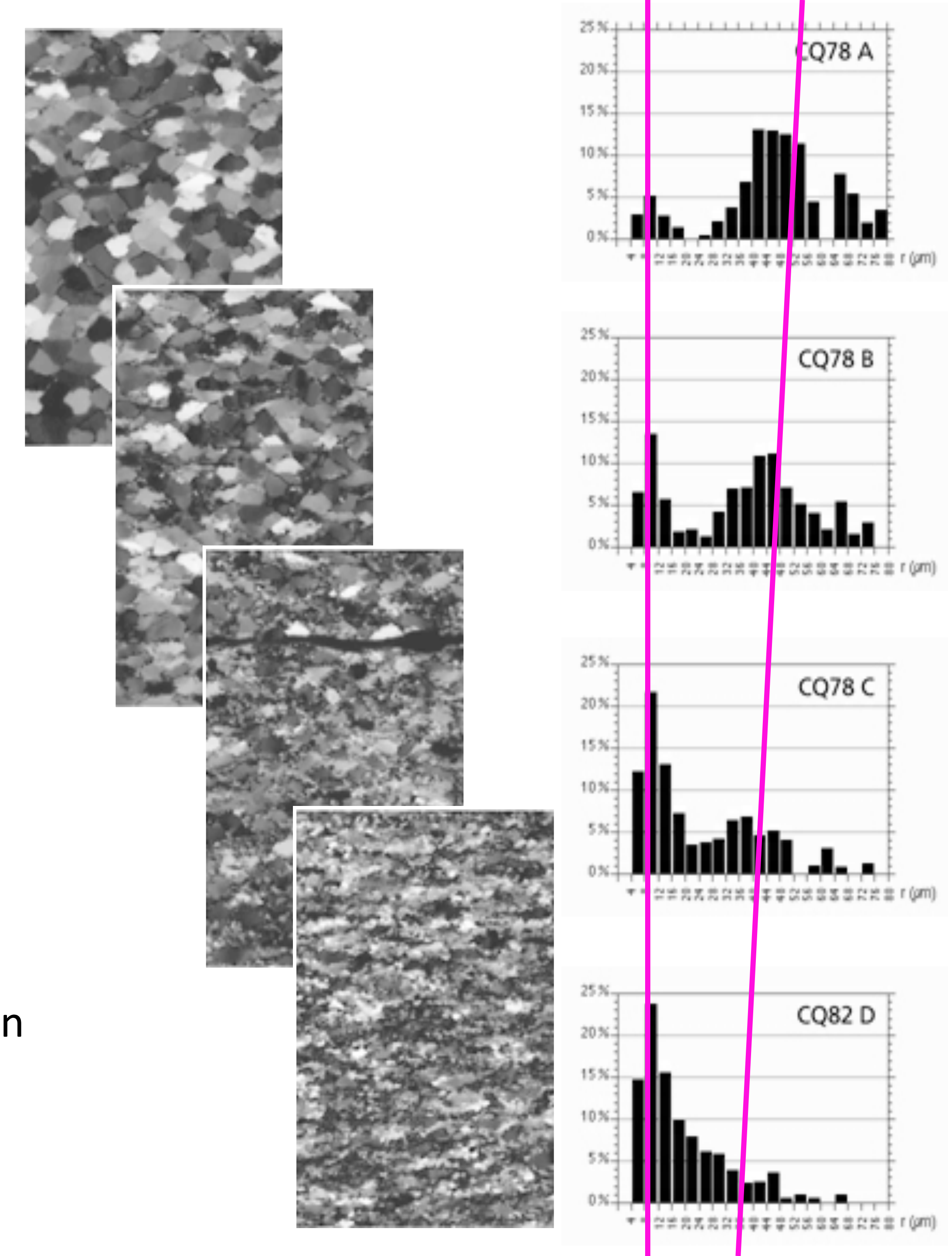


grain boundaries derived from 3 principal misorientation images

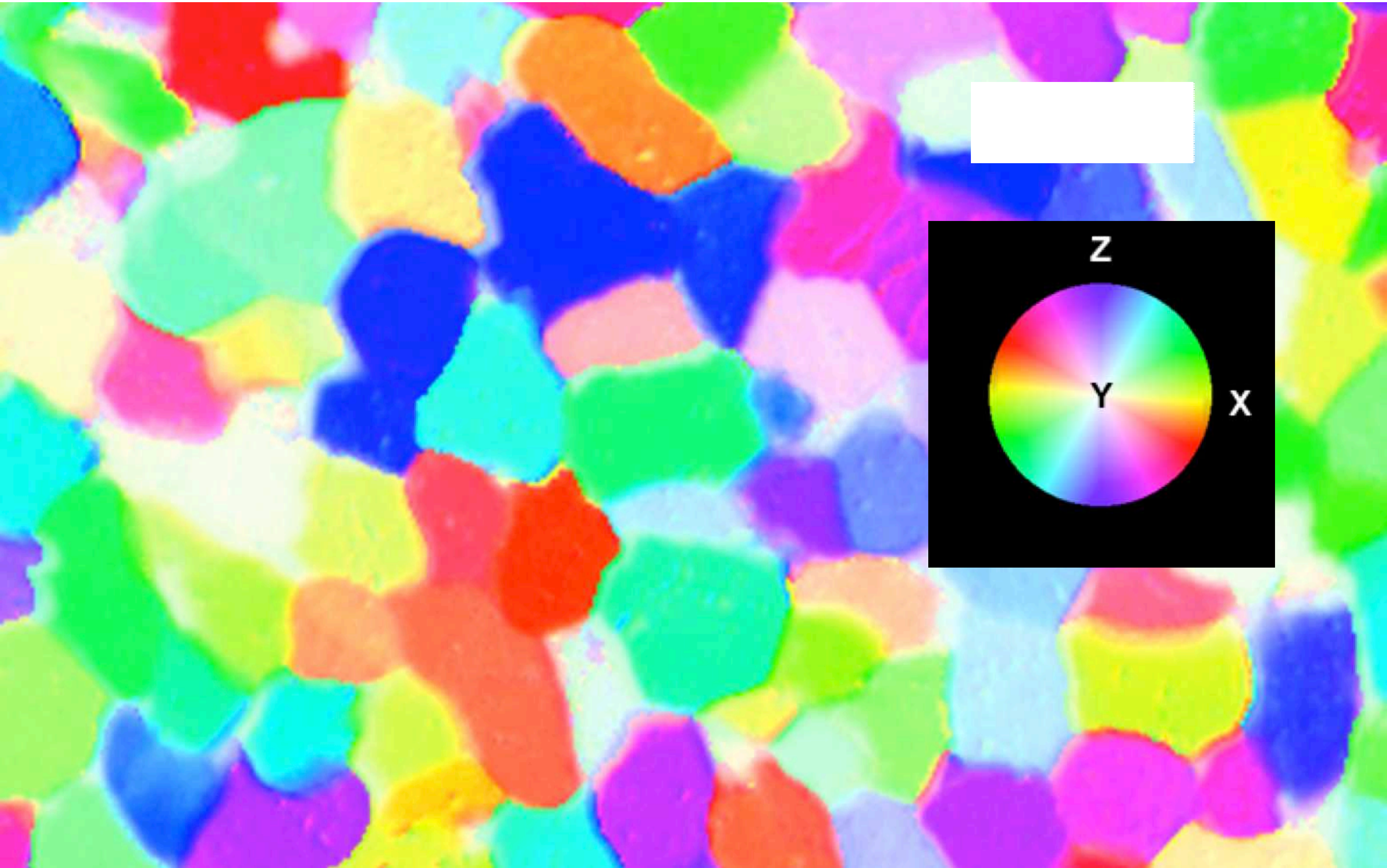
GRAIN SIZE ANALYSIS

LAZY GRAIN BOUNDARIES
(NIH Image macro)
create grain boundary map
from principal misorientation
images

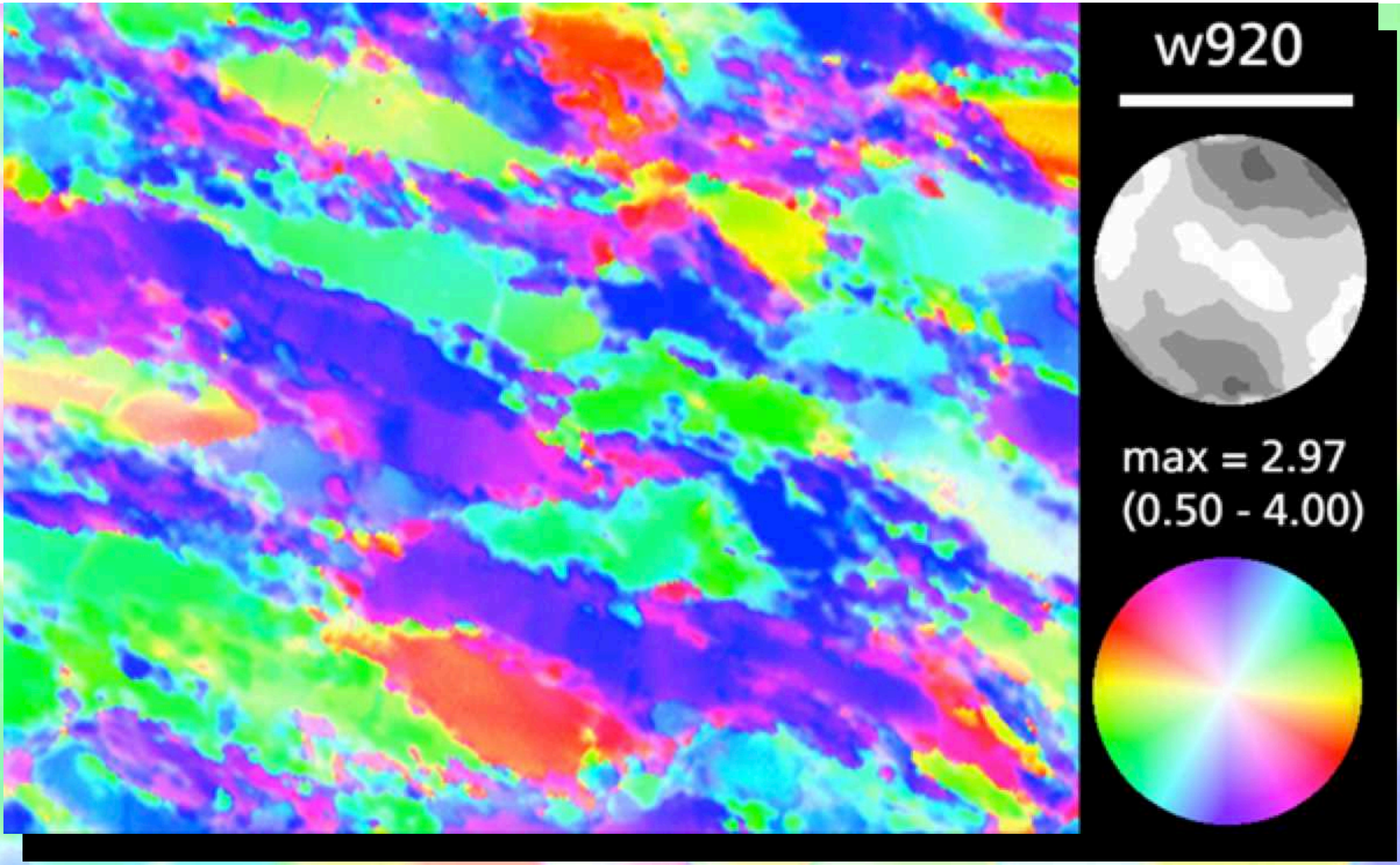
STRIPSTAR
(Fortran program)
calculate 3-D grain size distribution
from size distribution of sections



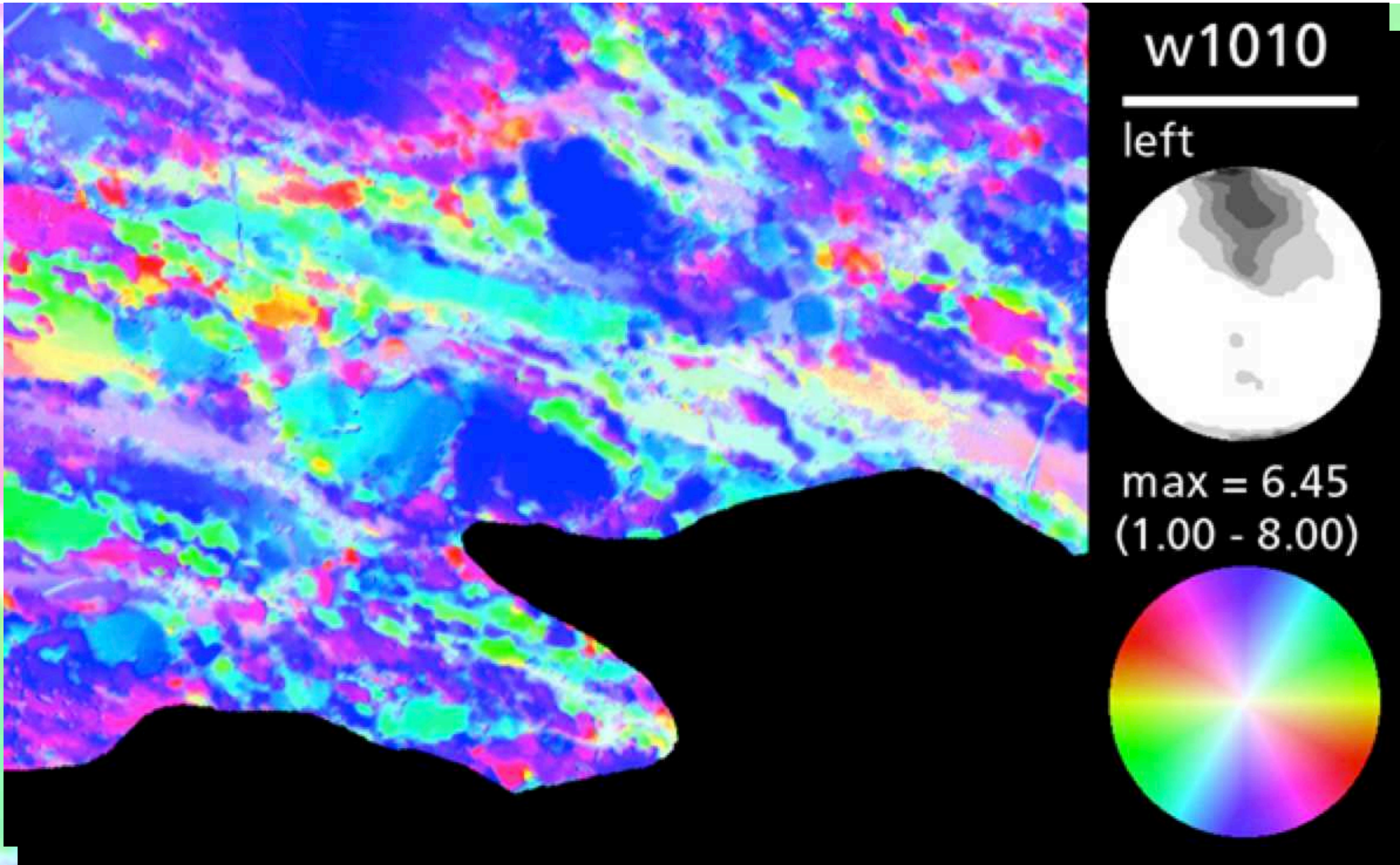
DEVELOPMENT OF CPO (experiments BHQ)



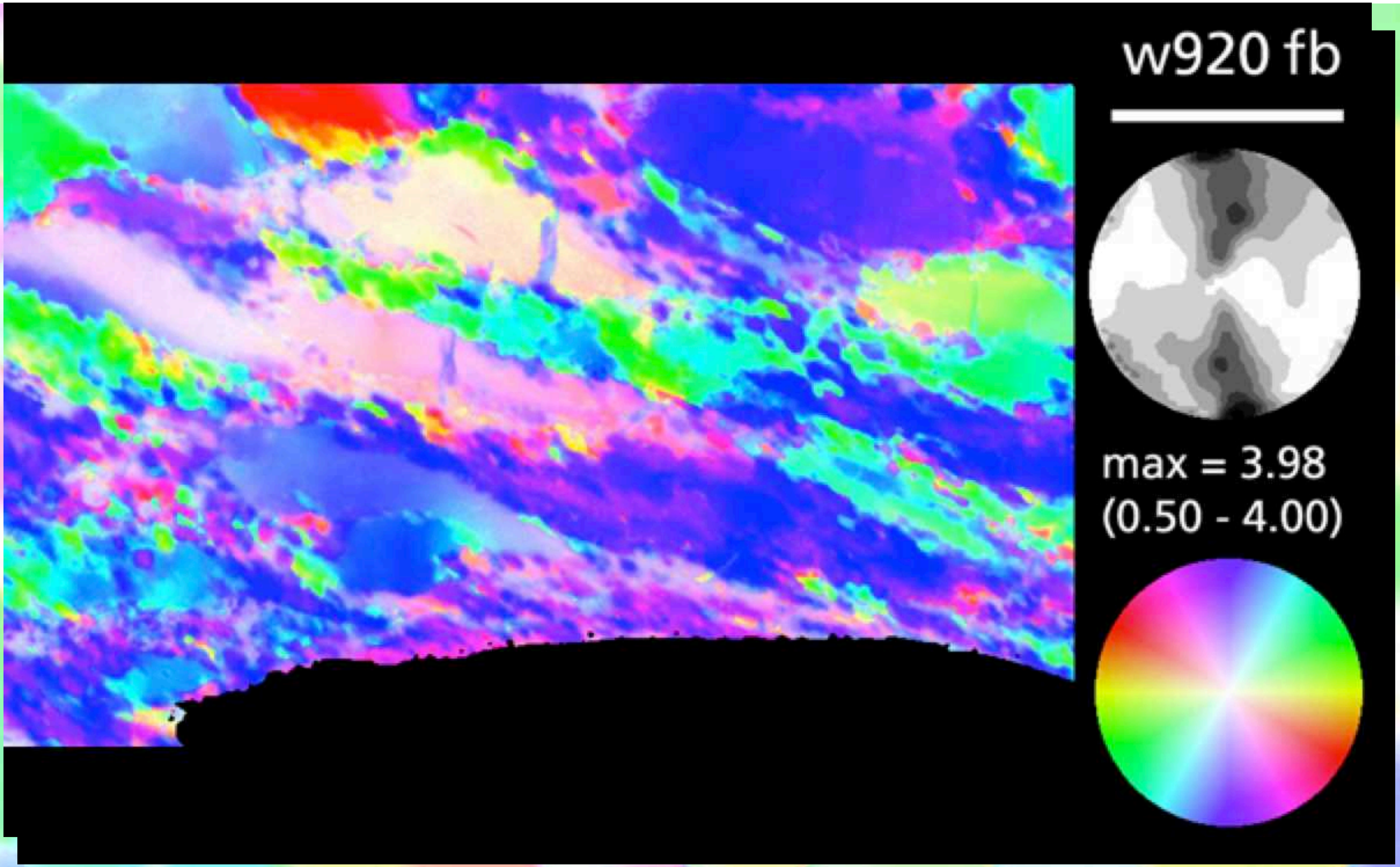
LOW DEFORMATION (γ = 1.5)



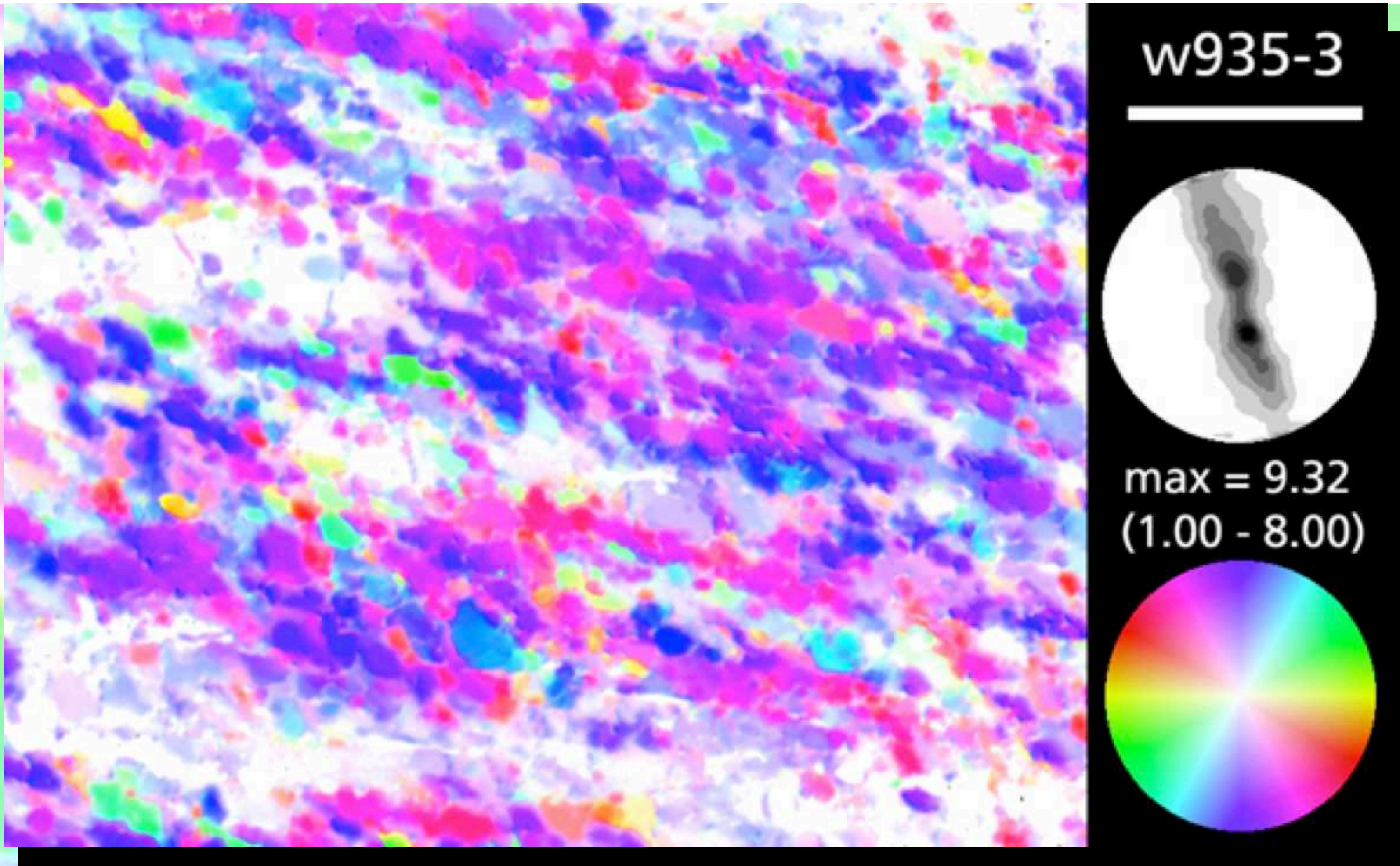
INTERMEDIATE DEFORMATION (γ = 2.5)



INTERMEDIATE DEFORMATION ($\gamma = 4$)



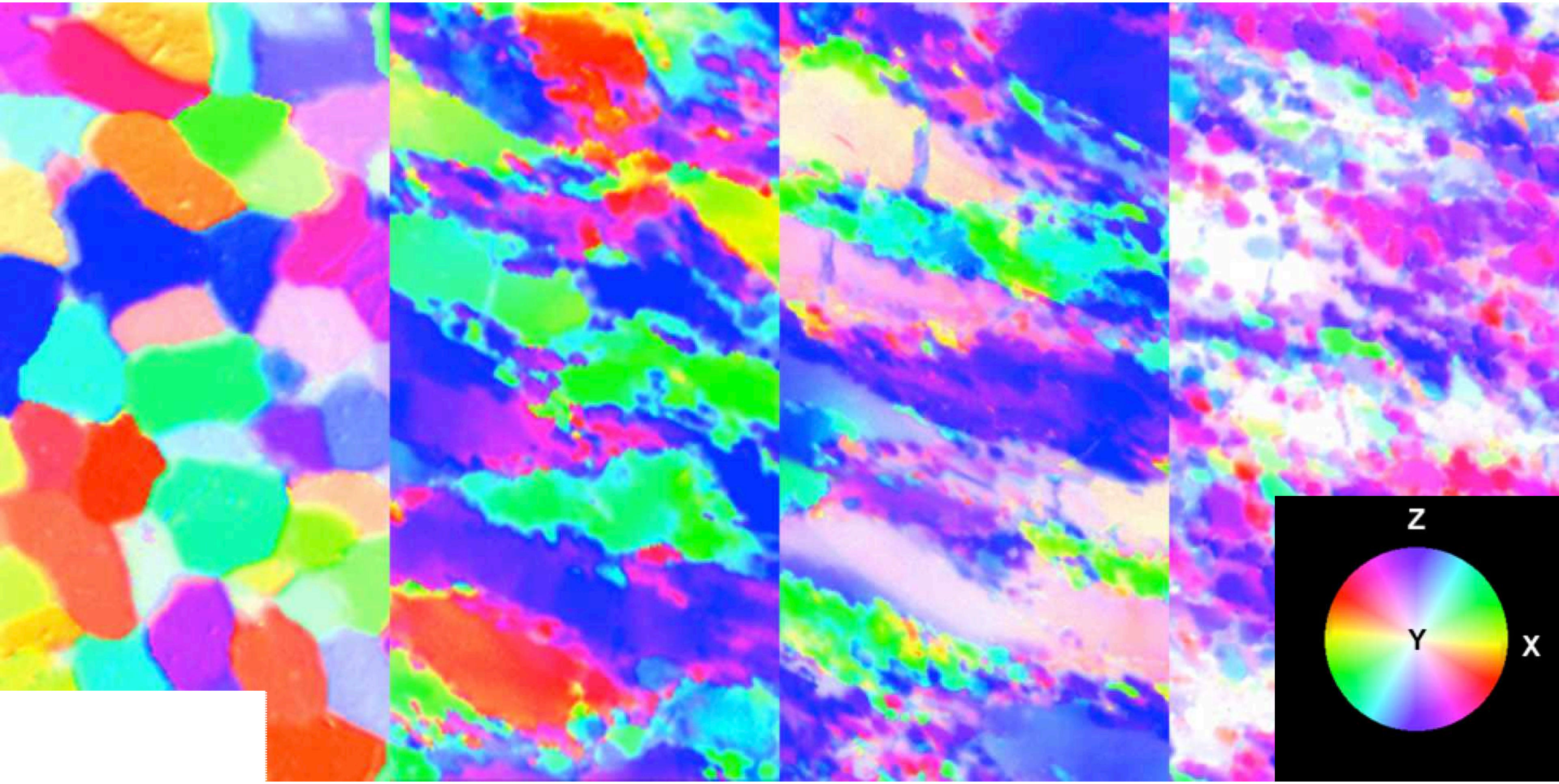
HIGH DEFORMATION ($\gamma = 6$)



!

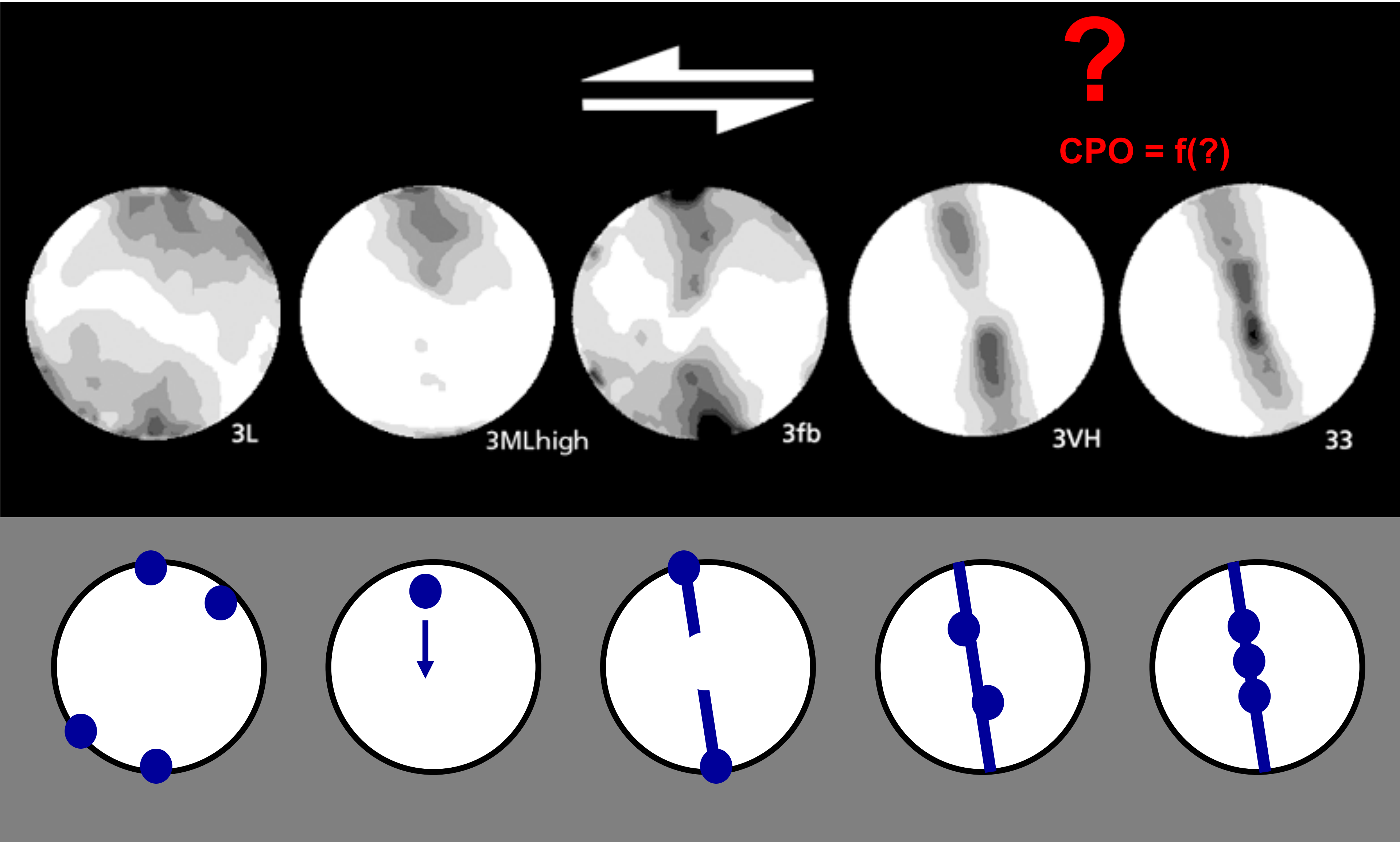
domain size

DEVELOPMENT OF MICROFABRIC

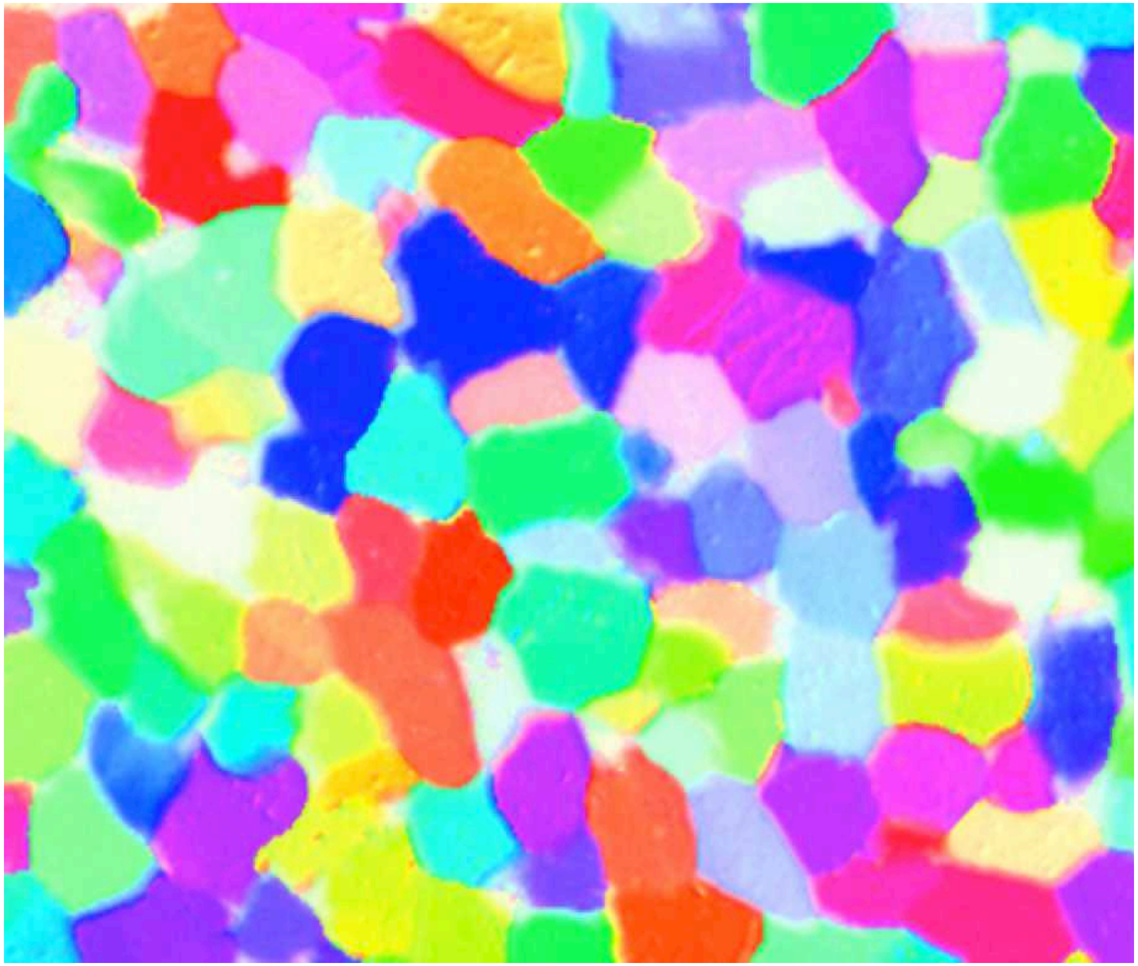


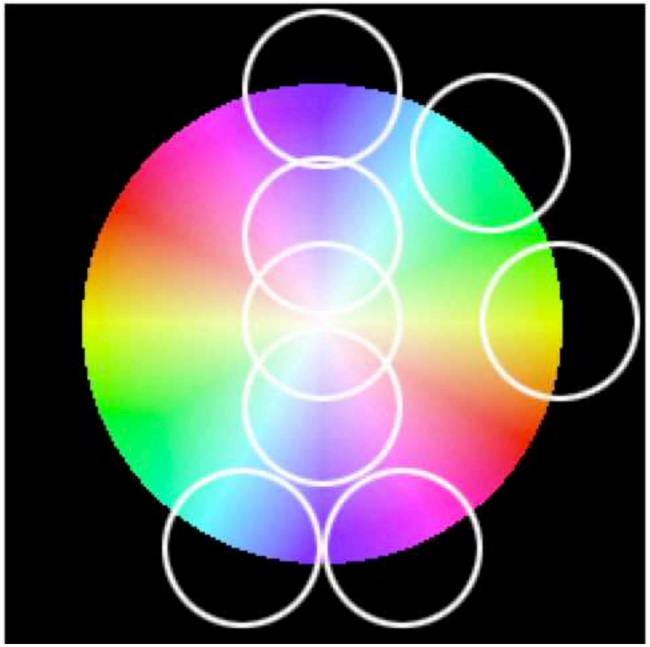
γ = 0 1.5 4 6

POLE FIGURE DEVELOPMENT



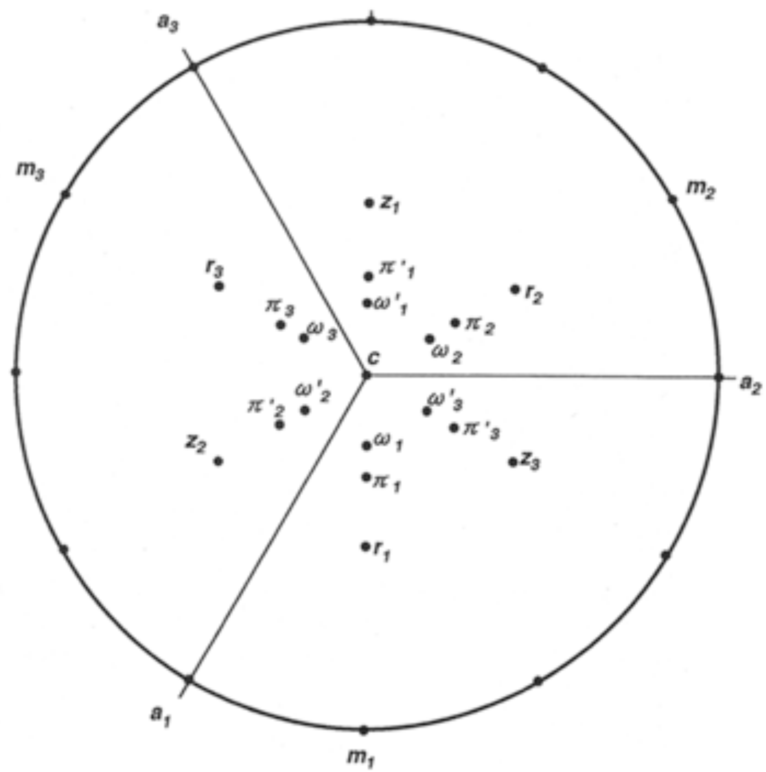
MISORIENTATION TRACKING

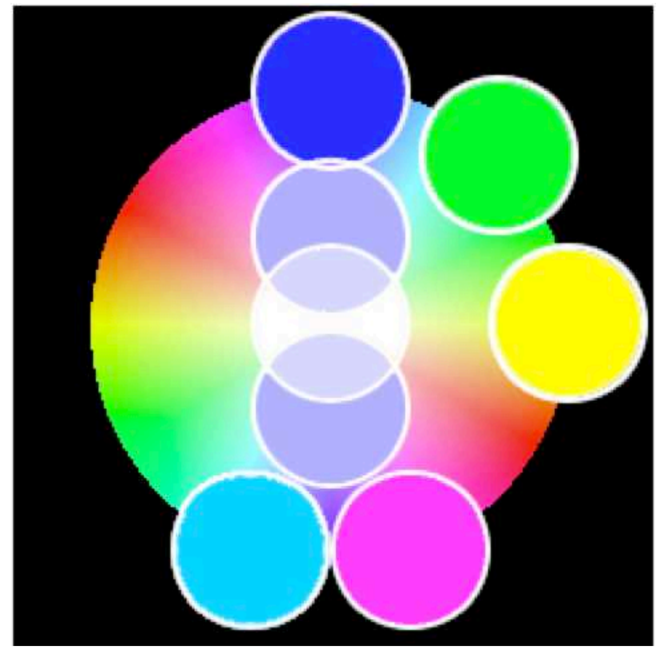


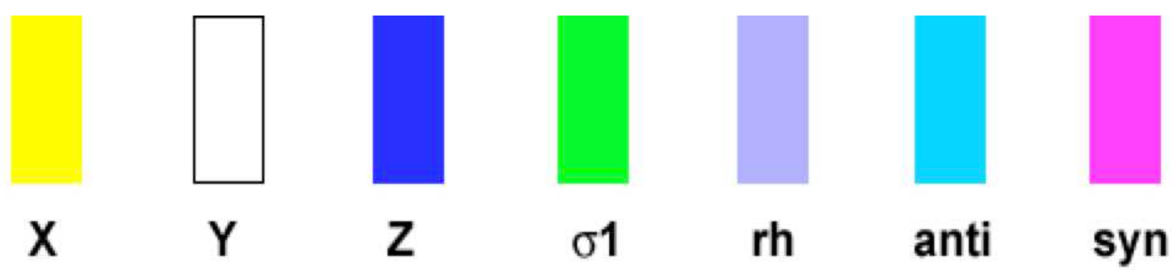


… using 60° cones

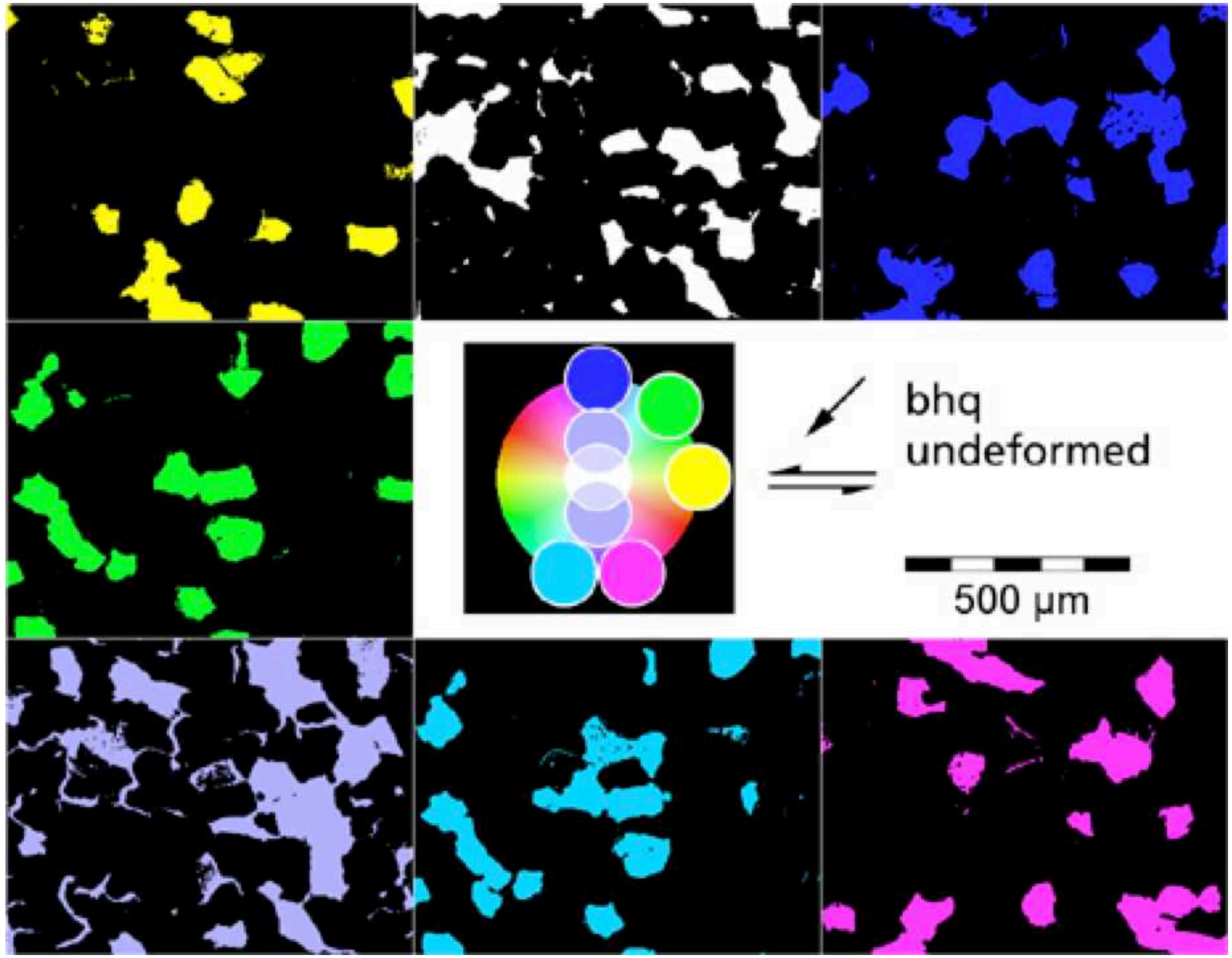
α -quartz



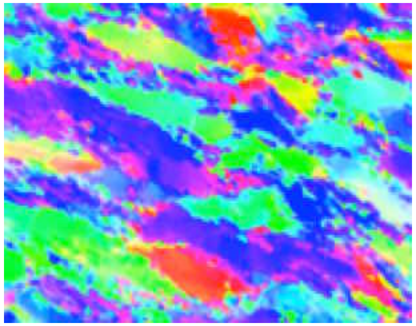




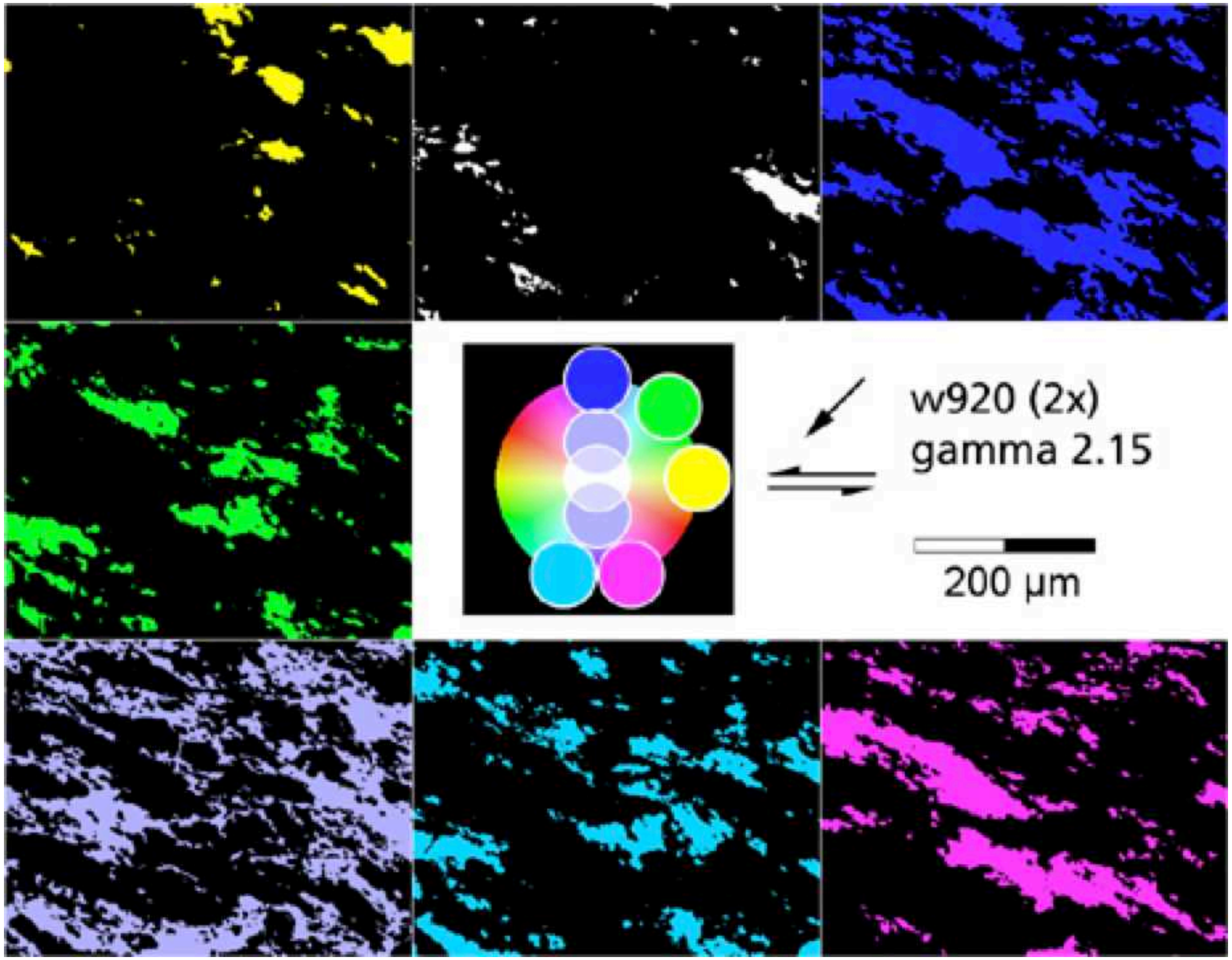
starting material = isotropic



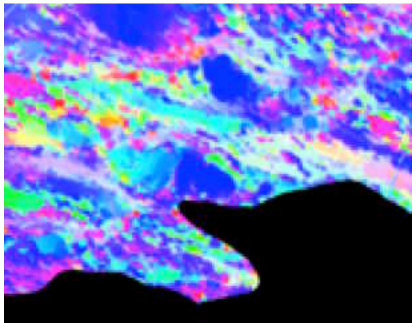
transitional porphyroclast fabric

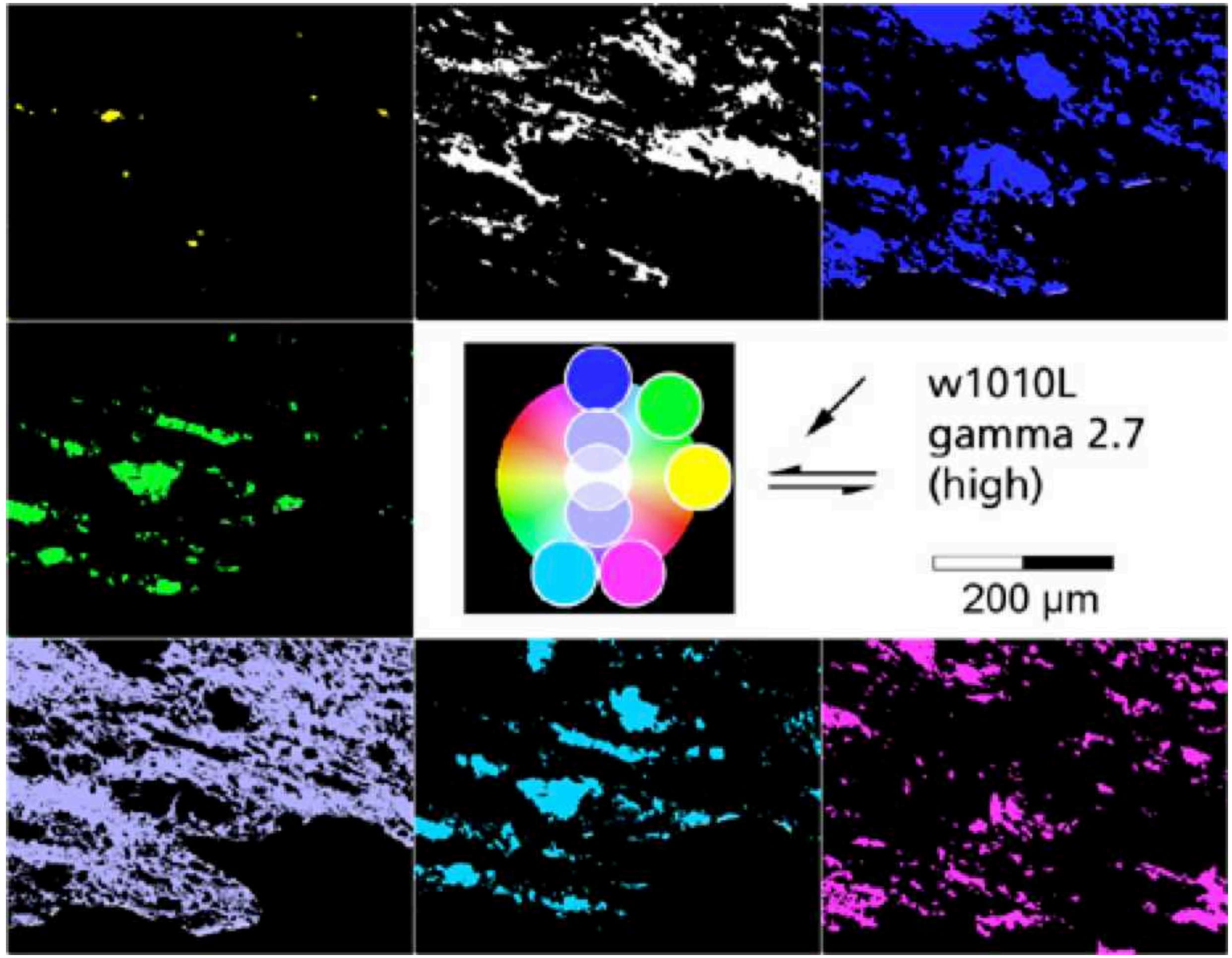


rexl

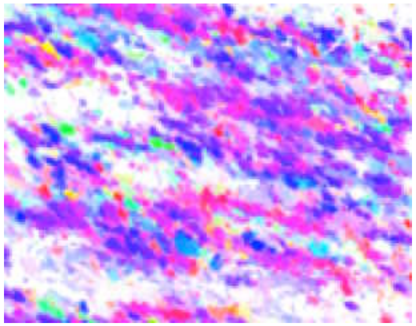


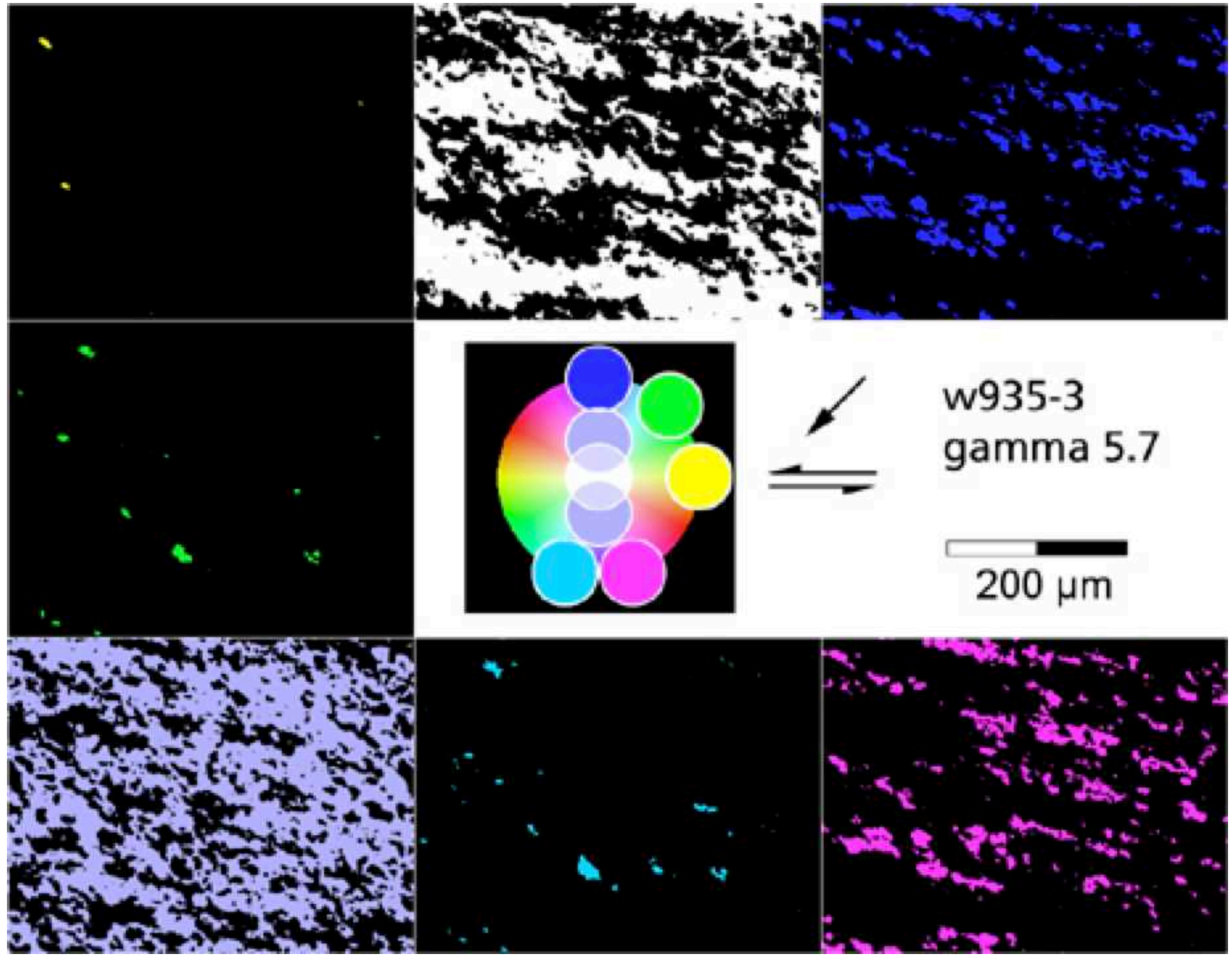
increasing recrystallization



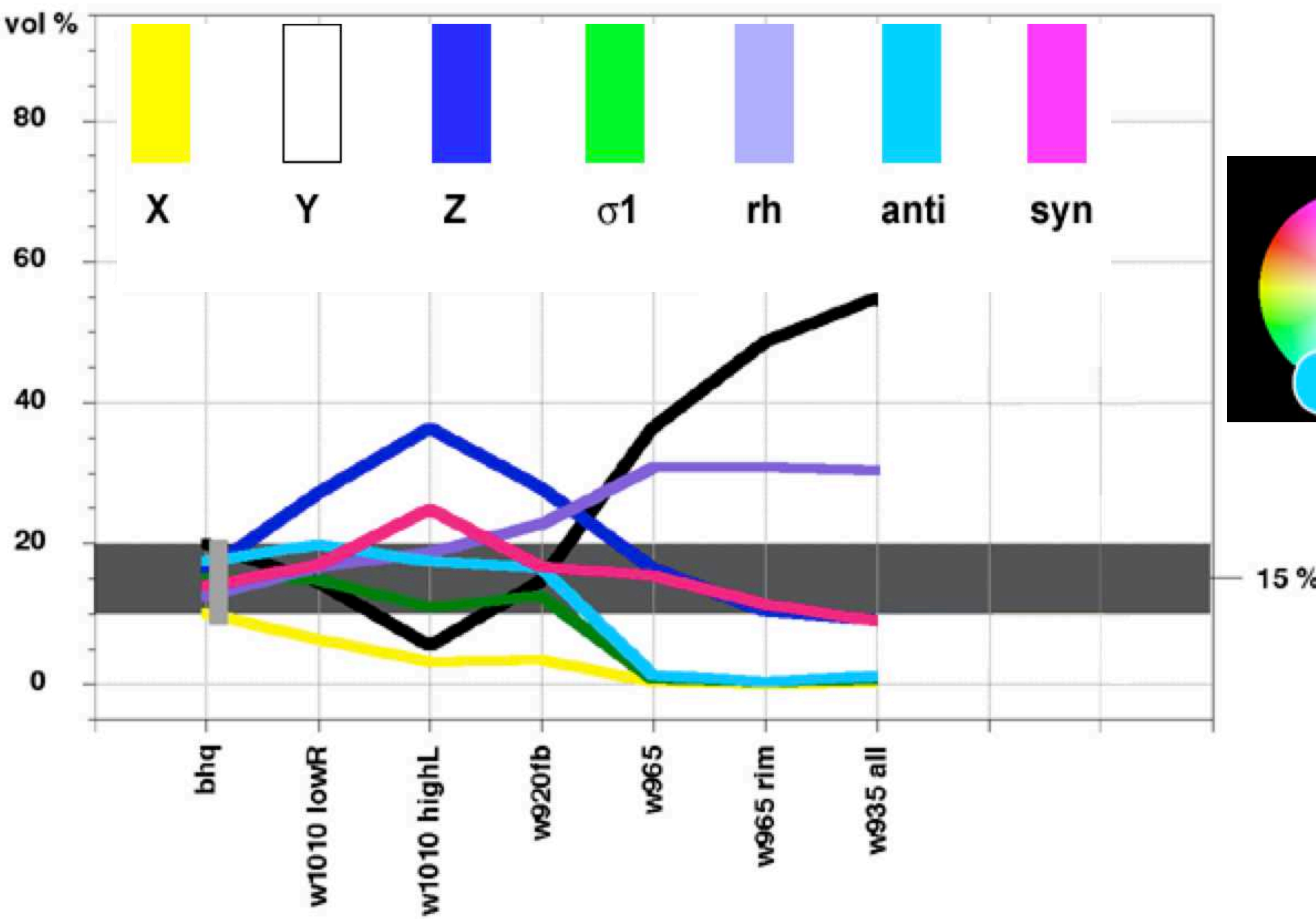


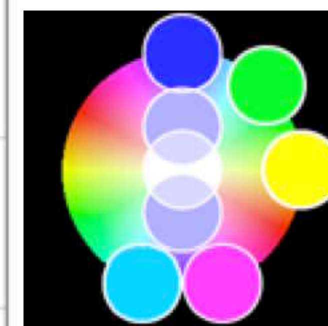
completely recrystallized



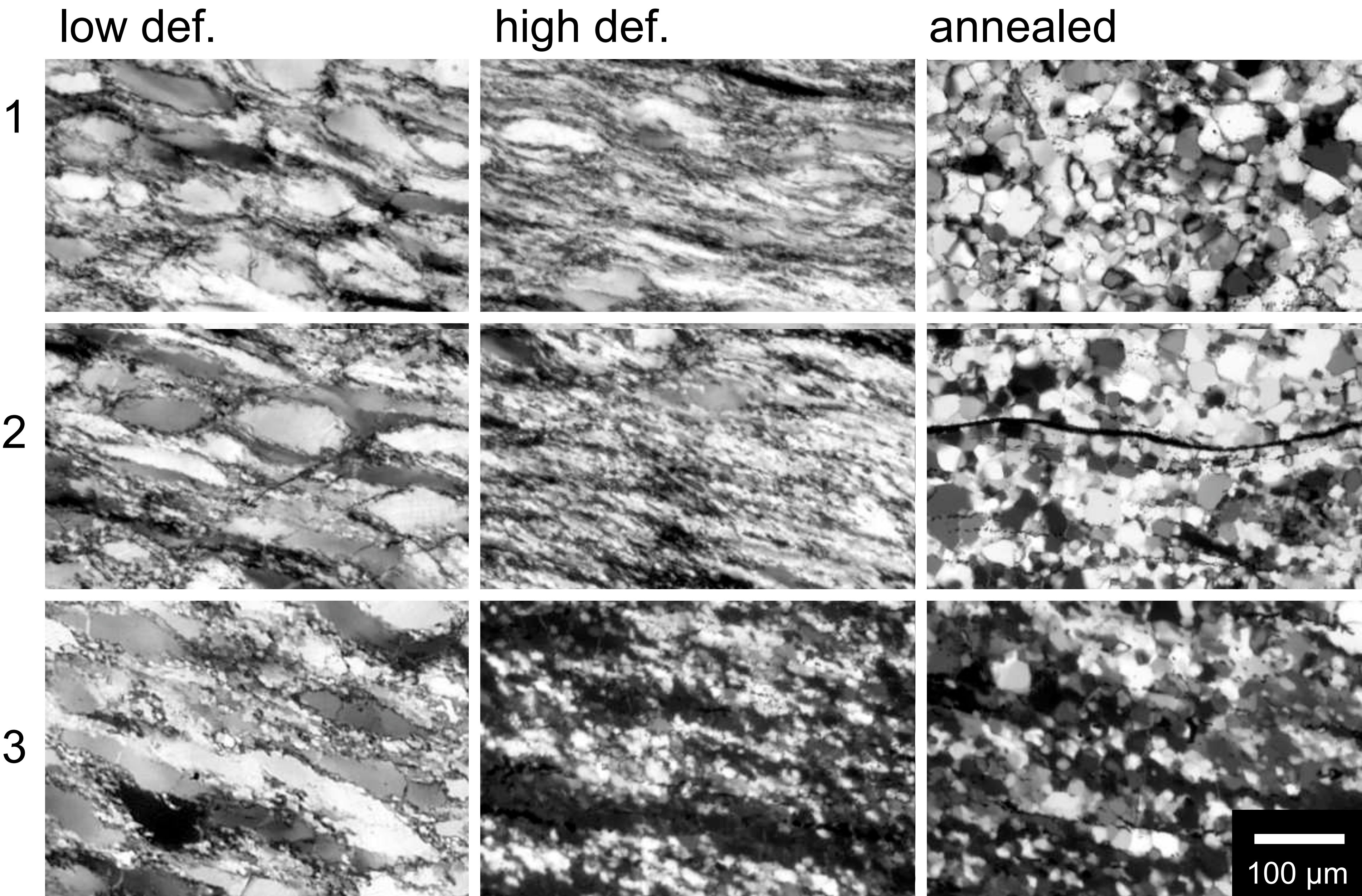


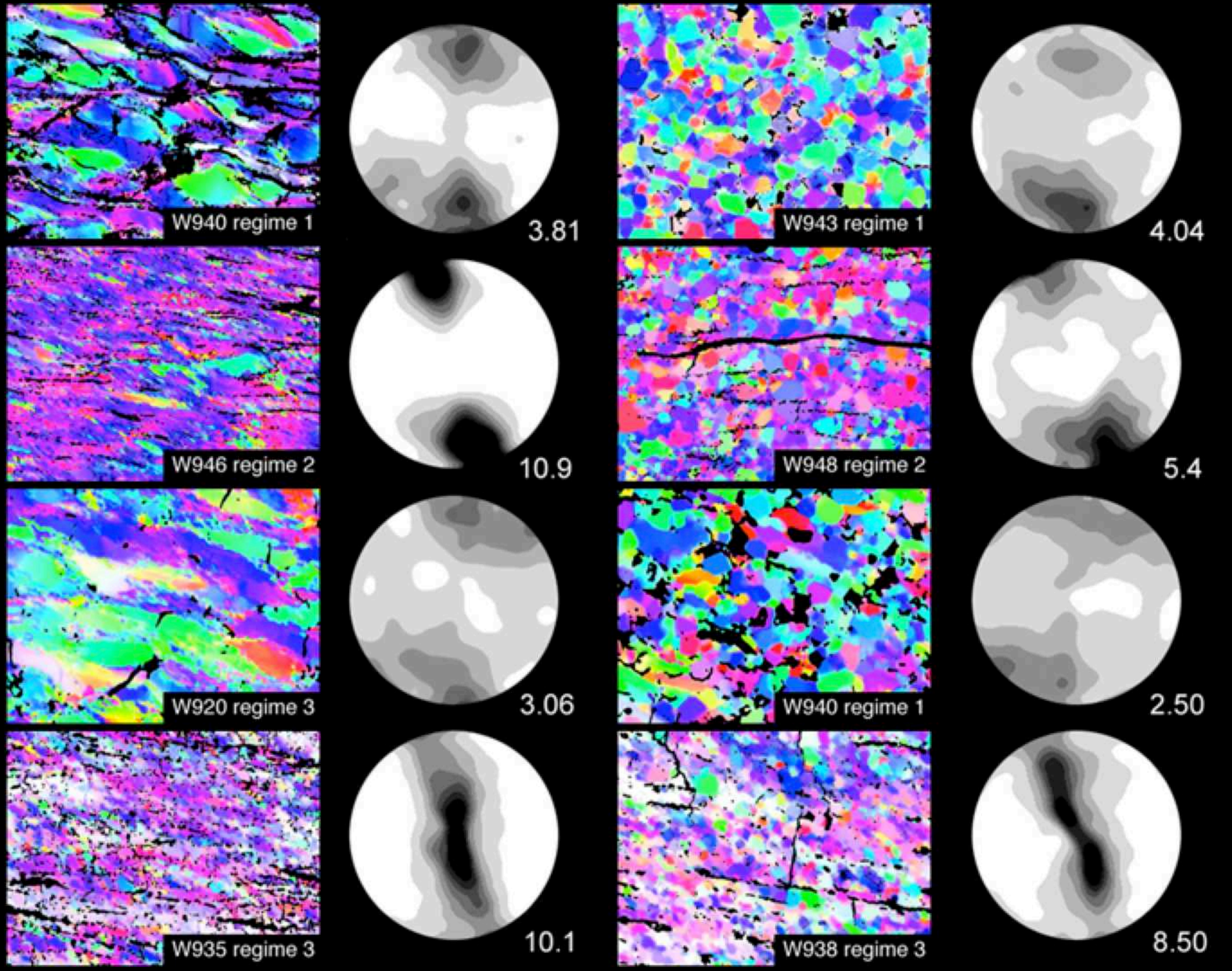
DEVLOPMENT OF CPO WITH DEFORMATION





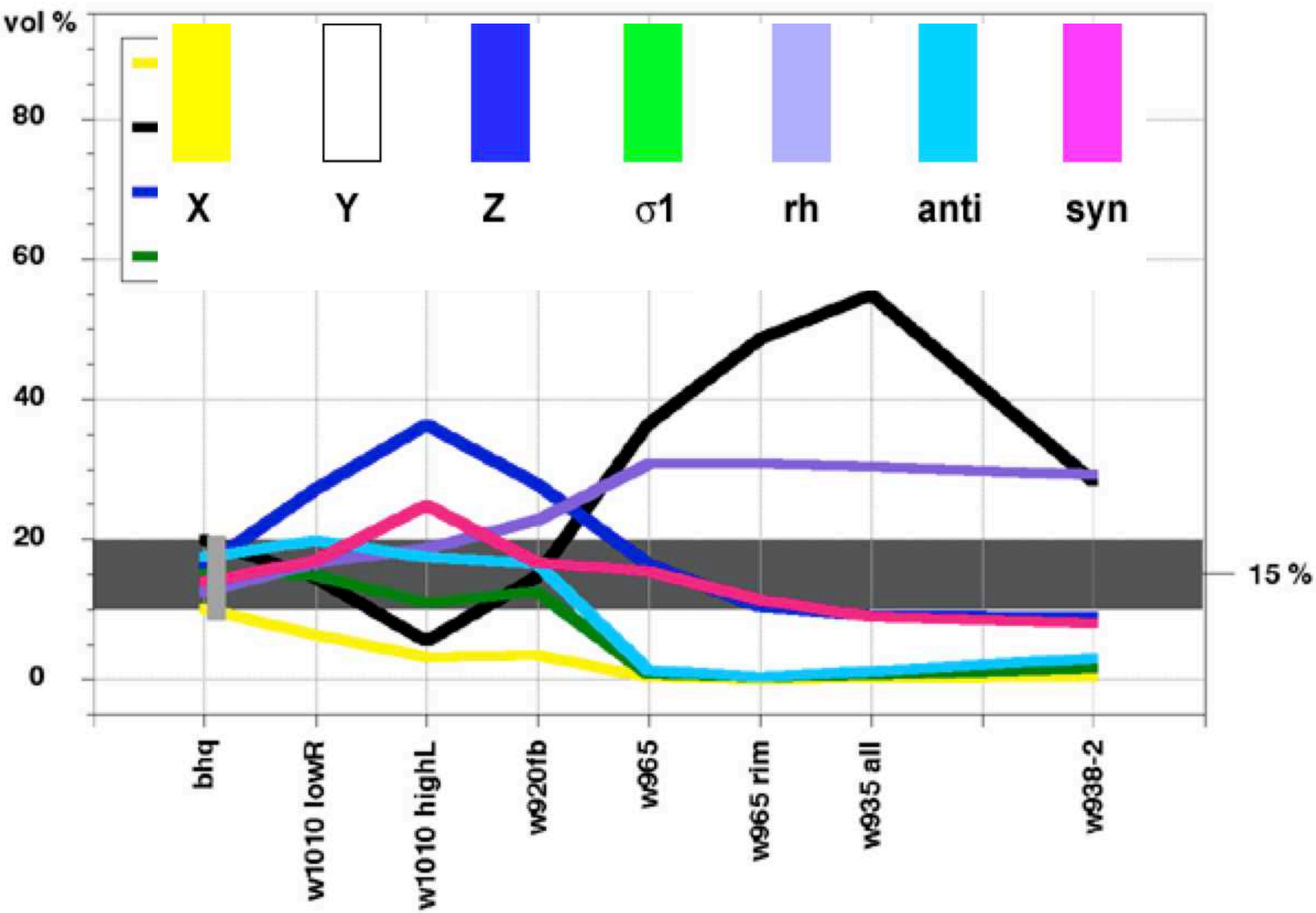
ANNEALING





W940 regime 1
3.81
W943 regime 1
4.04
W946 regime 2
10.9
W948 regime 2
5.4
W920 regime 3
3.06
W940 regime 1
2.50
W935 regime 3
10.1
W938 regime 3
8.50

CPO DEVELOPMENT



CONCLUSIONS

- CPO = f (STRAIN, $\Delta\sigma$, T, ε, … etc.)
- domains
- saturation of microstructure
- low T / regime: localization

  high T / regime: penetrative deformation
- annealing does not randomize fabric

experimental = natural rock deformation