

Orientation imaging: Measuring and mapping crystallographic orientations

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orientation imaging

1. optical / orientation imaging (CIP / EBSD)
2. CIP - computer-integrated polarization microscopy
 - a. CPO as function of shear strain (COI, pdf)
 - b. orientation tracking (misorientations)
 - c. piezometry (orientation gradients: gb density)
3. CIP and EBSD
 - a. visualize EBSD using CIP
 - b. kinematic directions: $\langle a \rangle$ axes
 - c. deformation of single crystal of quartz

orientation imaging



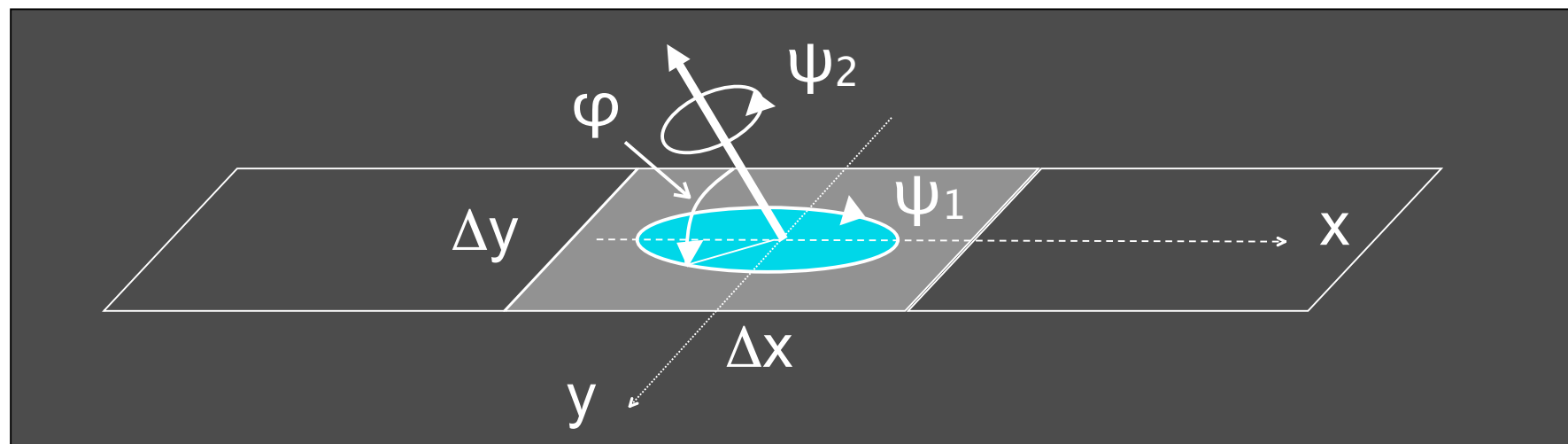
what is orientation imaging ?

orientation imaging is about the

localization of texture

Euler angles $(\psi_1, \varphi, \psi_2)$ -

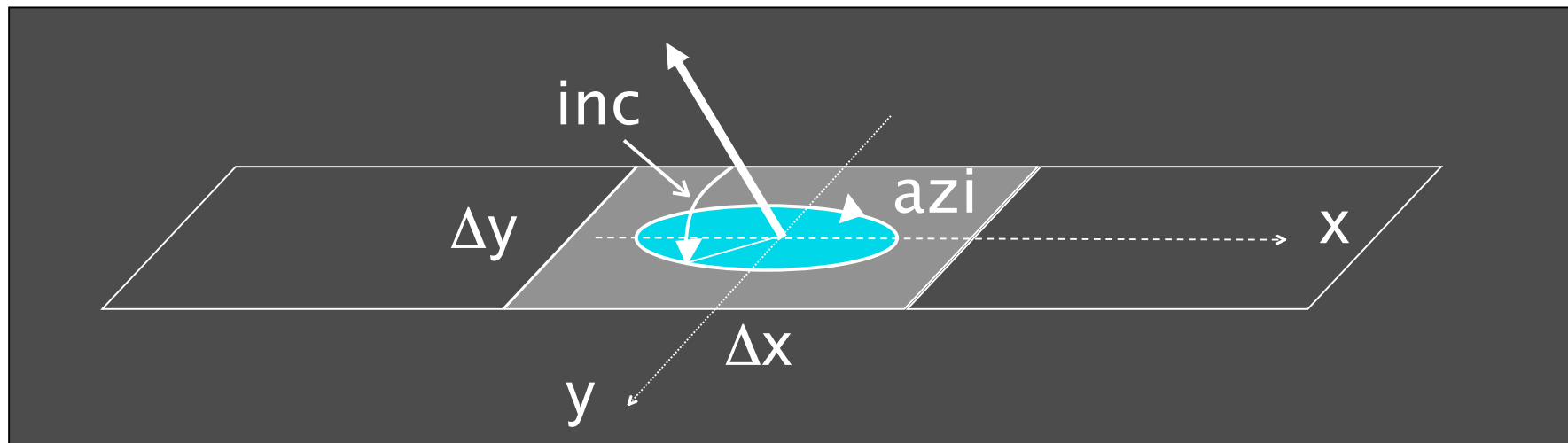
as a function of position in image plane (x, y)



what is optical orientation imaging ?

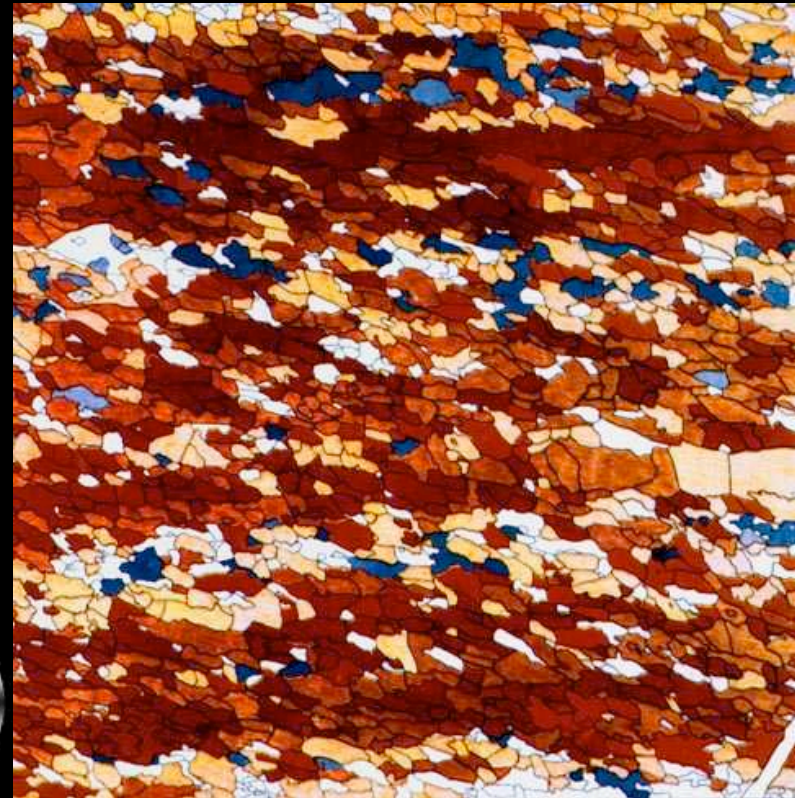
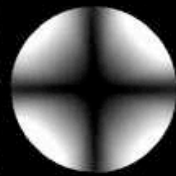
orientation imaging is about the

c-axis orientations (azi, inc) -
as a function of position in image plane (x, y)

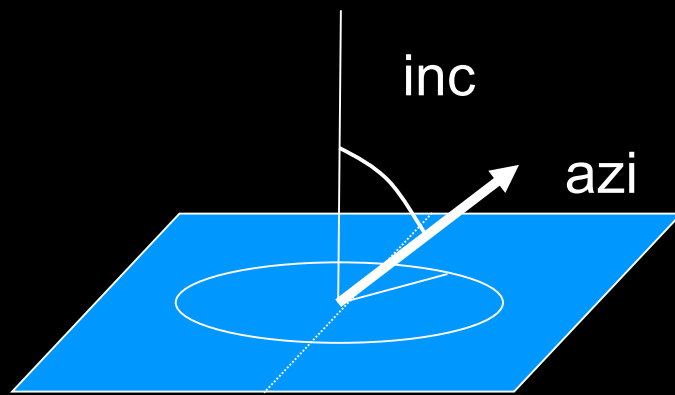


Achsenverteilungs-Analyse (AVA)

Bruno Sander

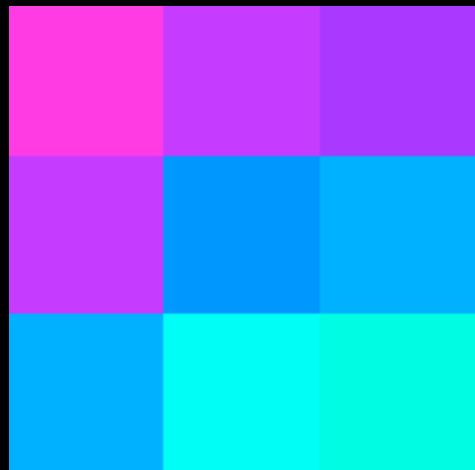


c-axis orientation image (COI)



orientation of optical axis
(of uniaxial mineral)
w/r to image coordinates

2 image planes
2-D colour look-up table
(CLUT)



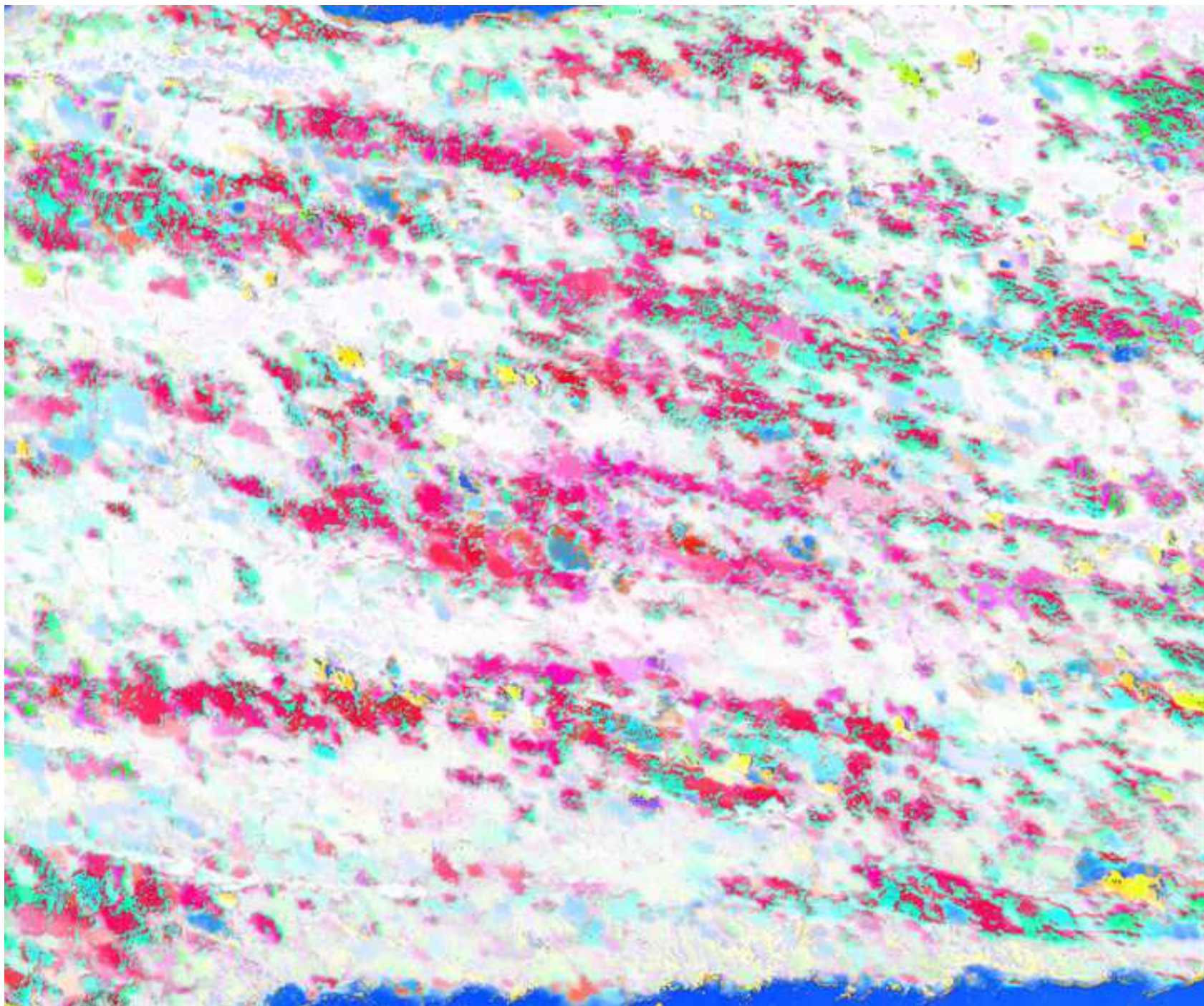
	83	85	84
121	110	97	36
90	40	32	93
35	0	170	

inc plane

azi plane



2-D CLUT



w935
cip1Awrap0
5-98%



max=12.9
cont.1 - 8



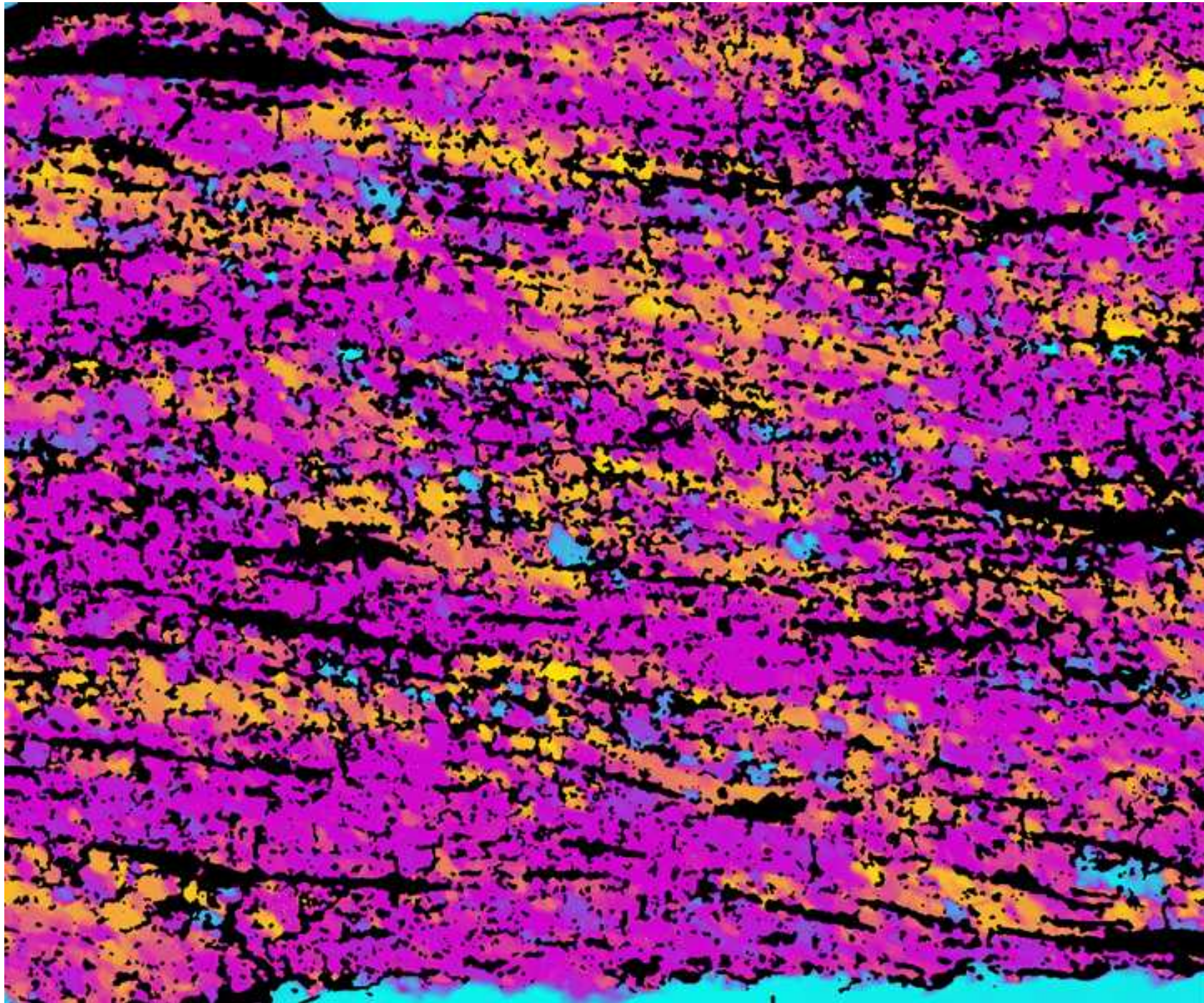


w935
cip | Awrap0
5-98%



max=12.9
cont. 1 - 8





w935
cip | Awrap0
5-98%



max= 8.8
cont. | - 8
polcorr 3



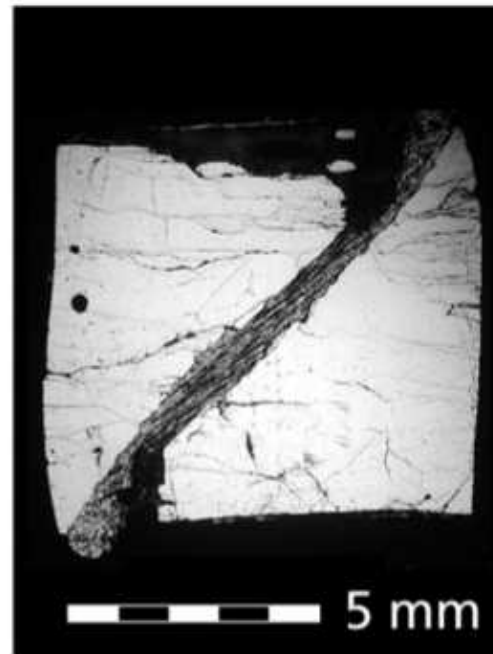
CIP and cook !

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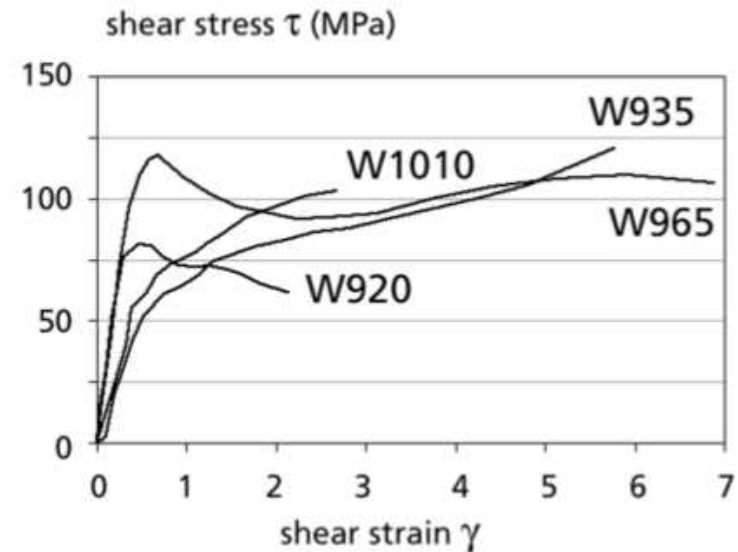
the experiments: Black Hills quartzite (BHQ)



a



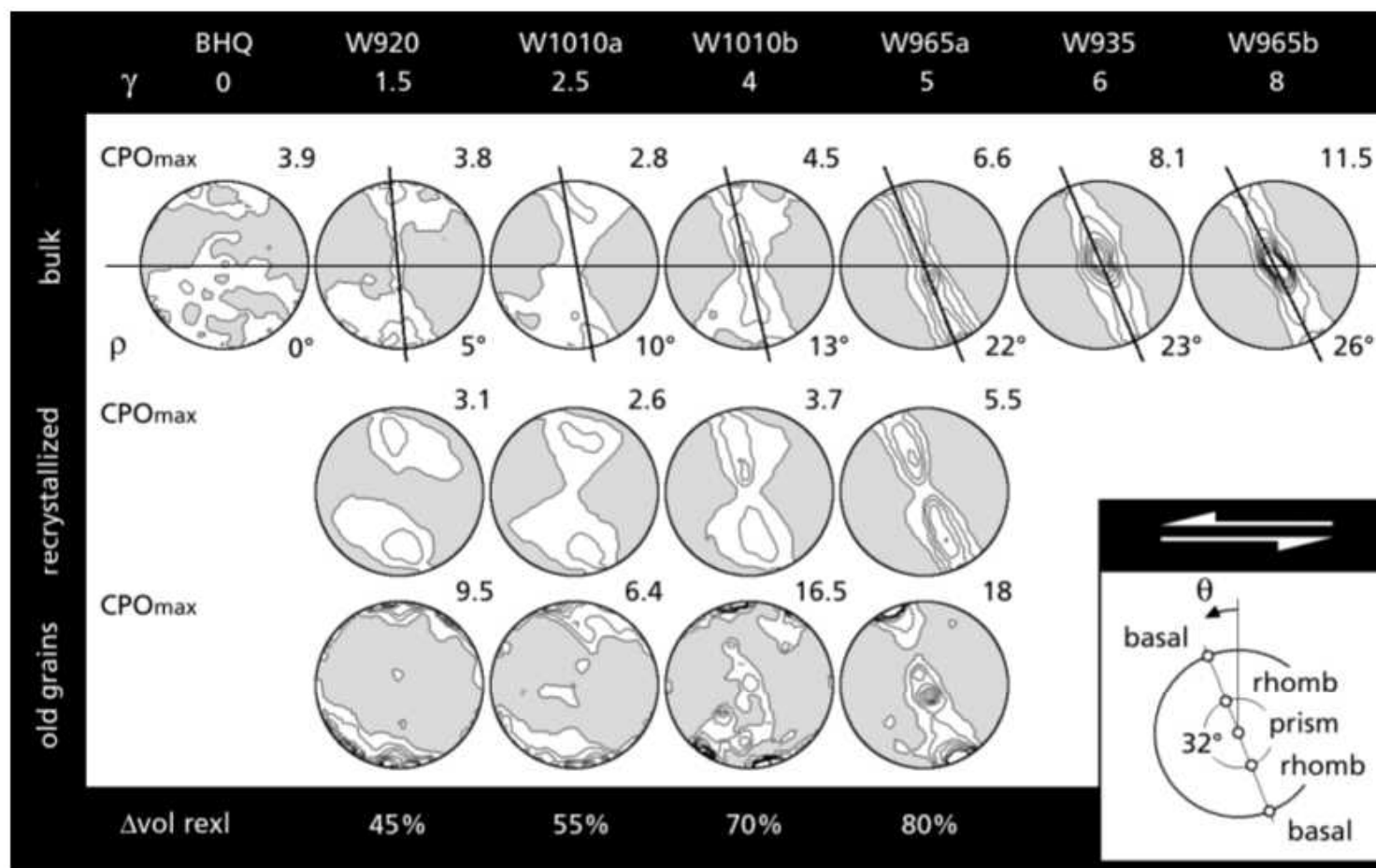
b



JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 111, B10202, doi:10.1029/2005JB004194, 2006

Evolution of c axis pole figures and grain size during dynamic recrystallization: Results from experimentally sheared quartzite

Renée Heilbronner¹ and Jan Tullis²



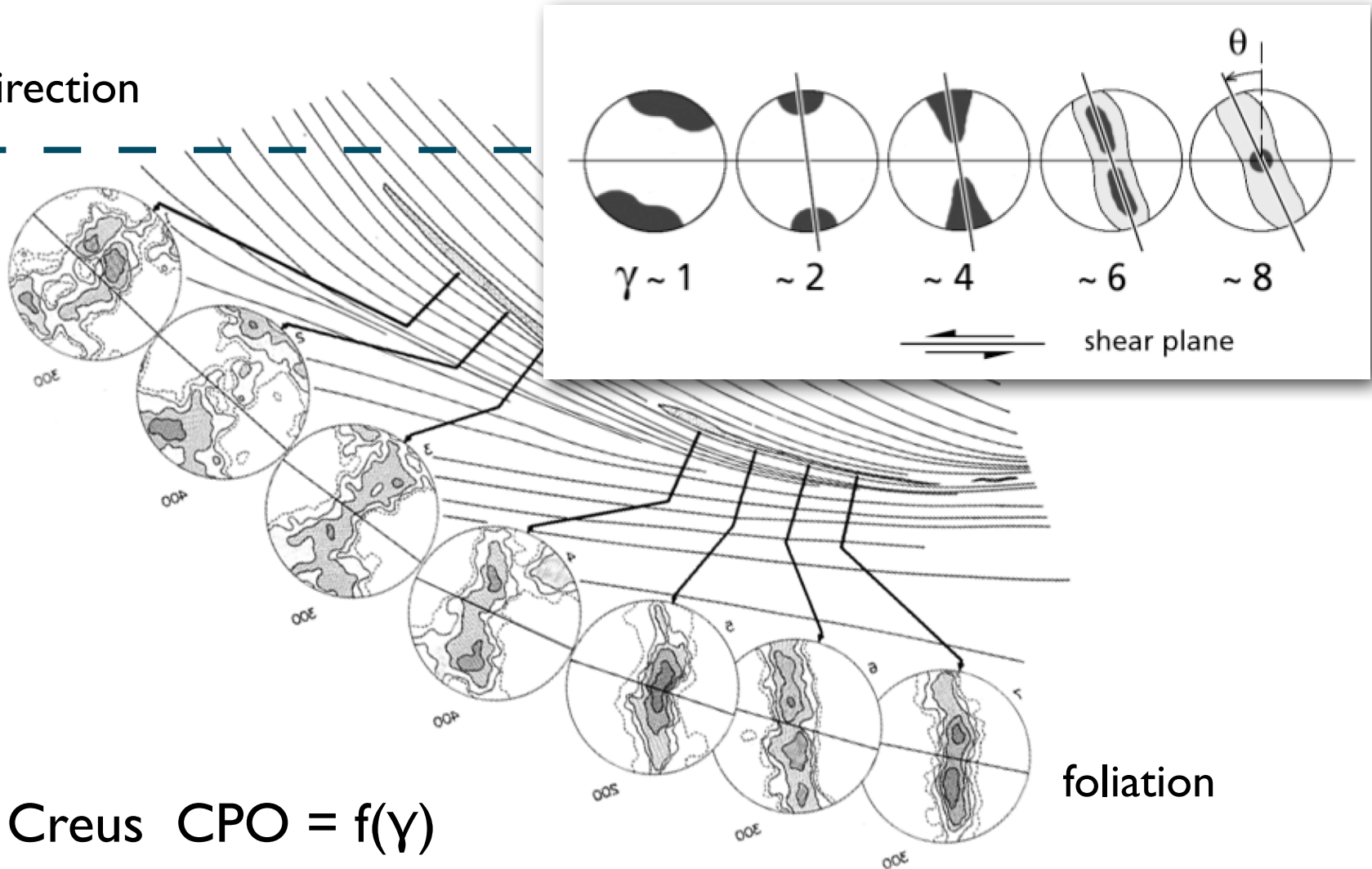
JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 111, B10202, doi:10.1029/2005JB004194, 2006

Evolution of c axis pole figures and grain size during dynamic recrystallization: Results from experimentally sheared quartzite

Renée Heilbronner¹ and Jan Tullis²

comparison nature - experiment

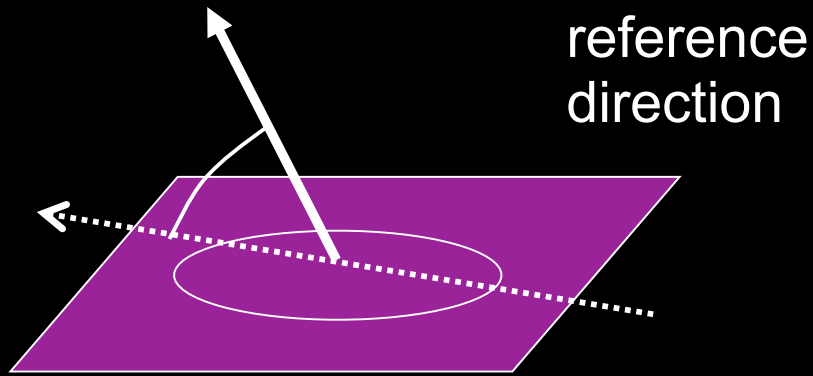
shear direction



foliation

Cap de Creus CPO = $f(\gamma)$
(Garcia Celma, 1982)
(Carreras & Garcia Celma, 1982)

c-axis misorientation image (COI)



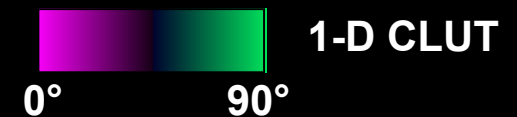
angular difference of orientation of c-axis with respect to external or internal reference direction

I image plane
I-D CLUT



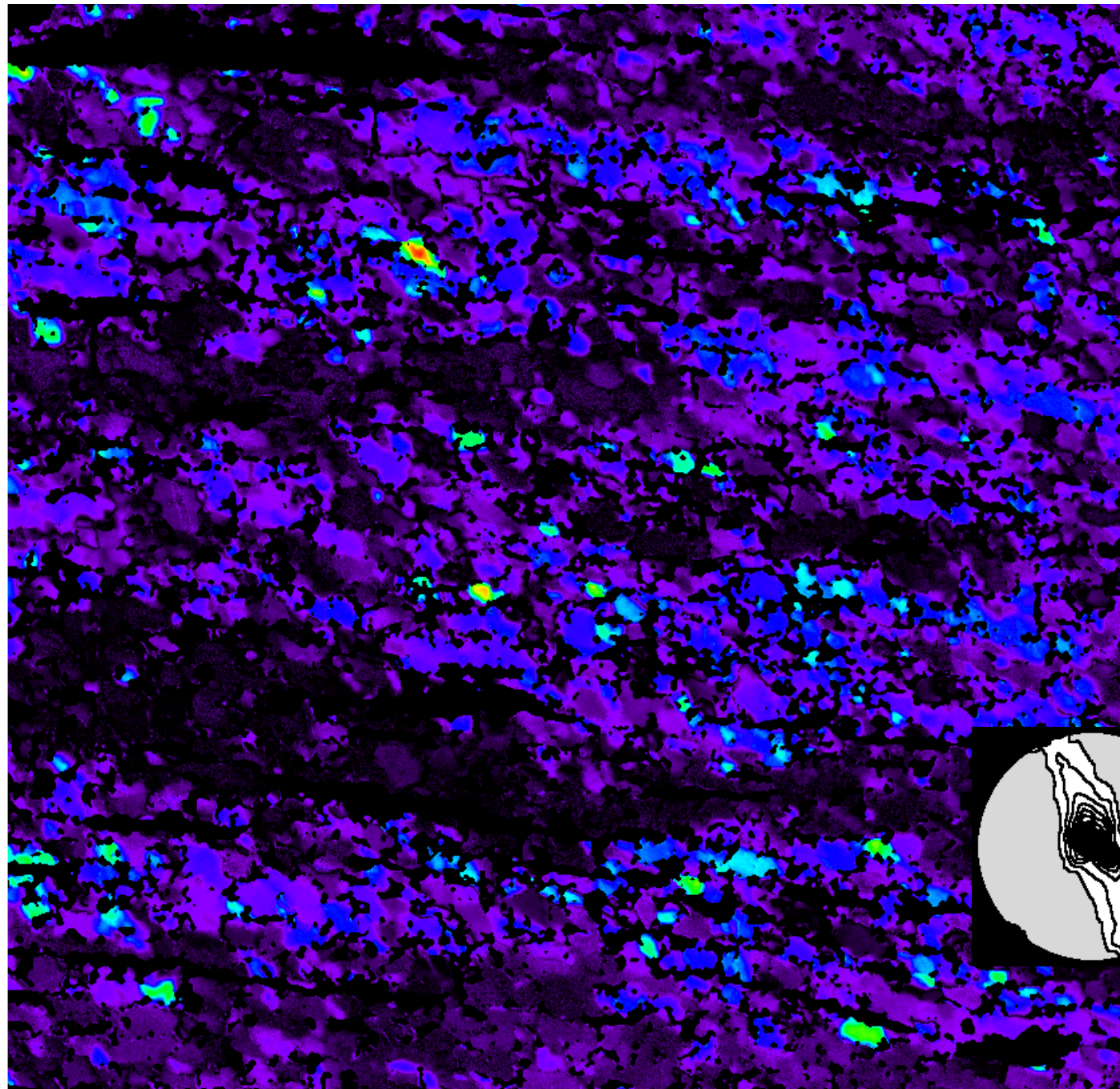
35	32	53
31	33	45
5	40	67

misor plane

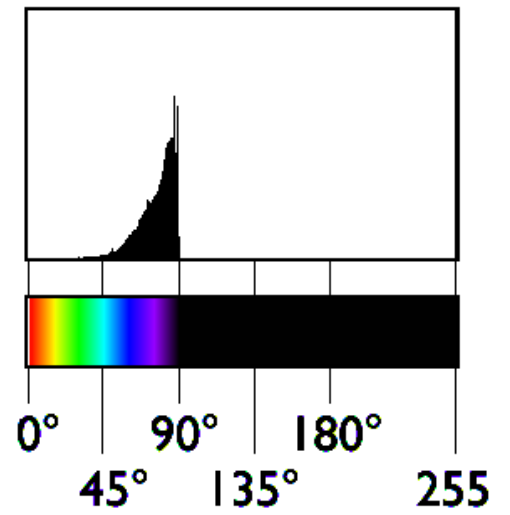


2-D CLUT

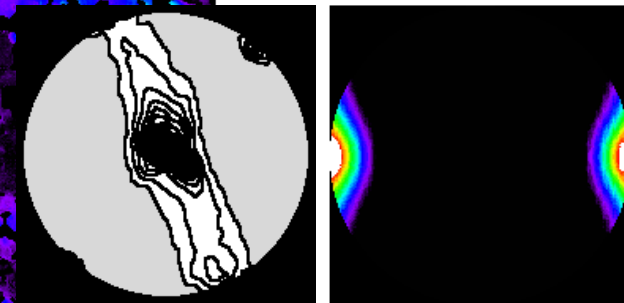
principal misorientations: external directions



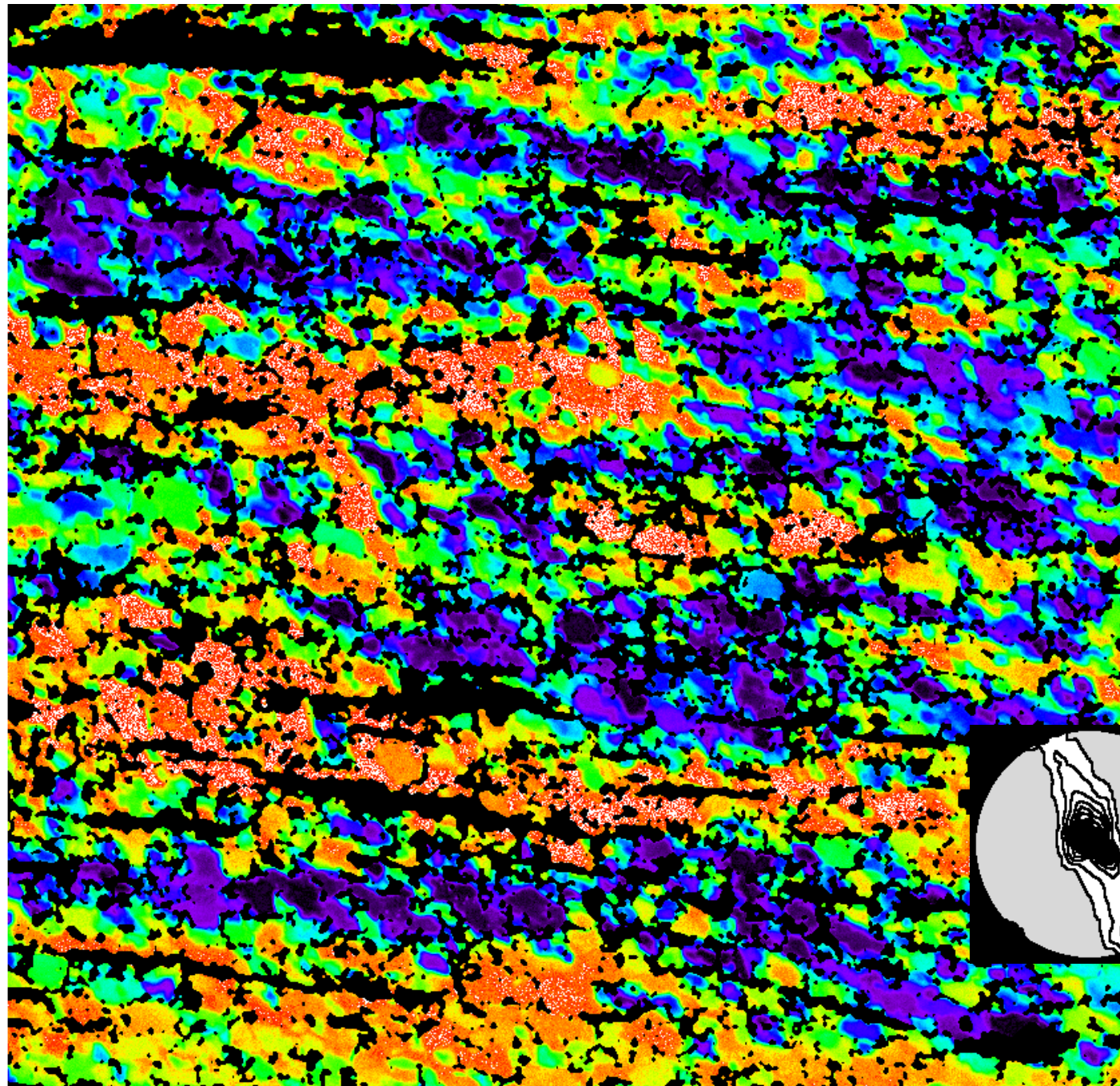
misE



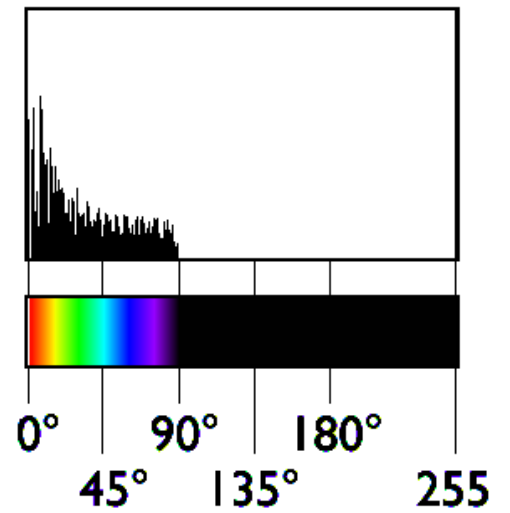
cip2



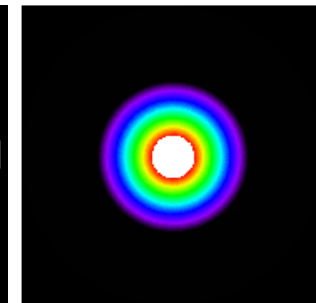
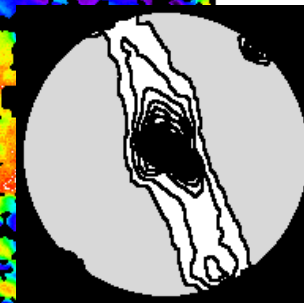
principal misorientations: external directions



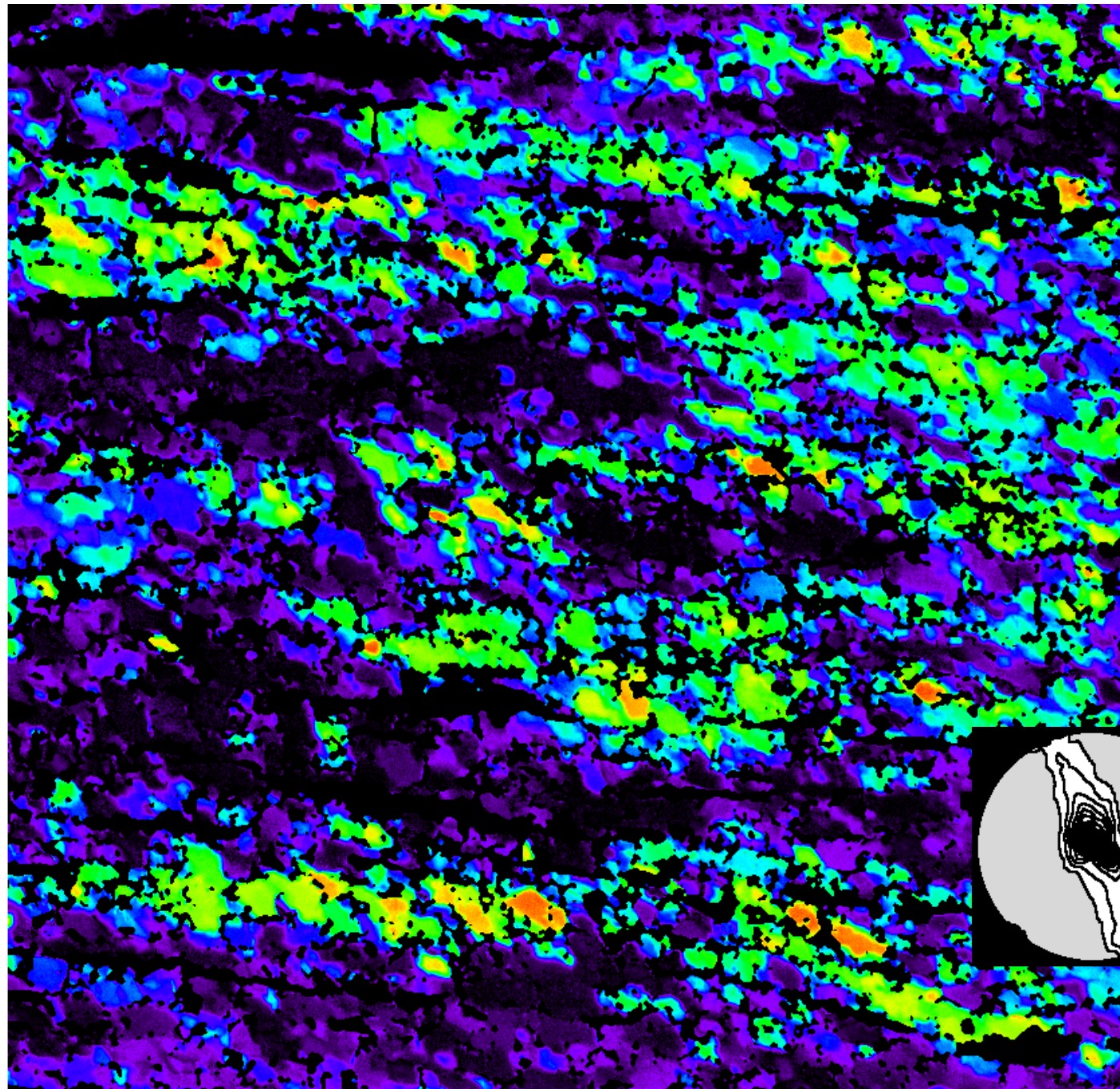
misH



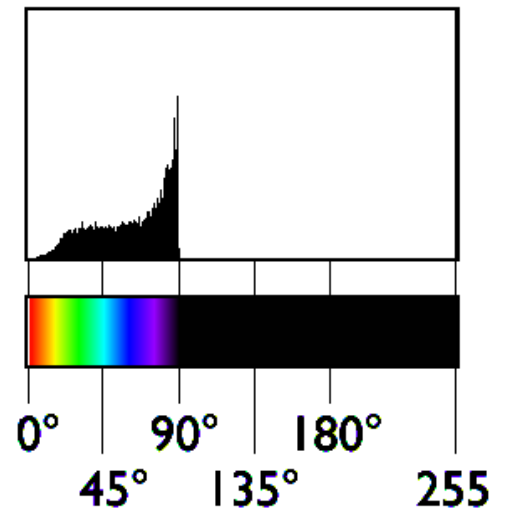
cip2



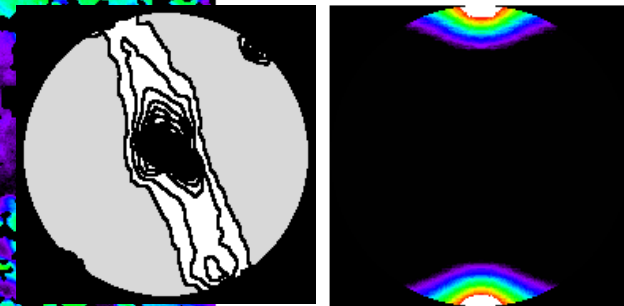
principal misorientations: external directions



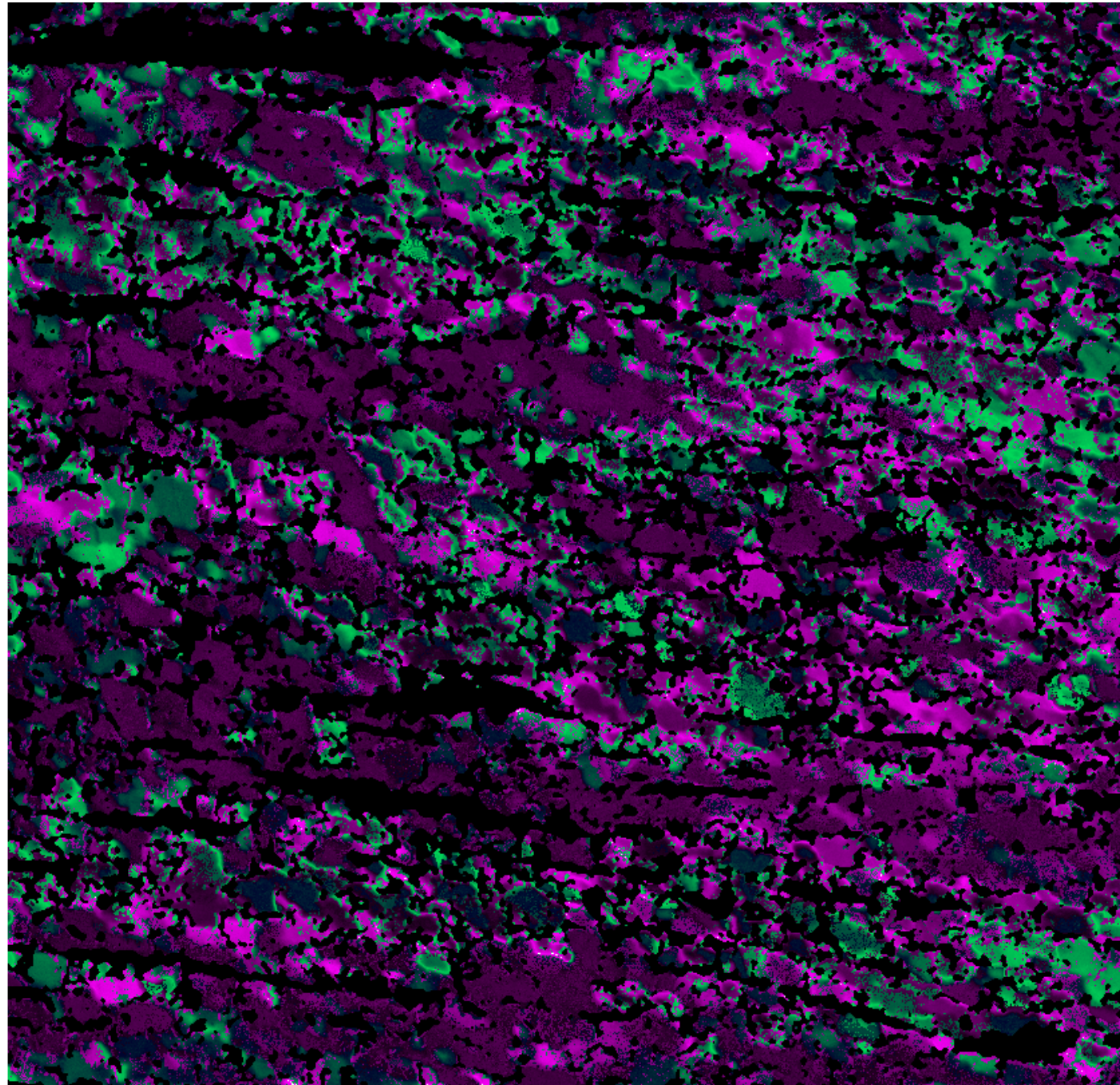
misN



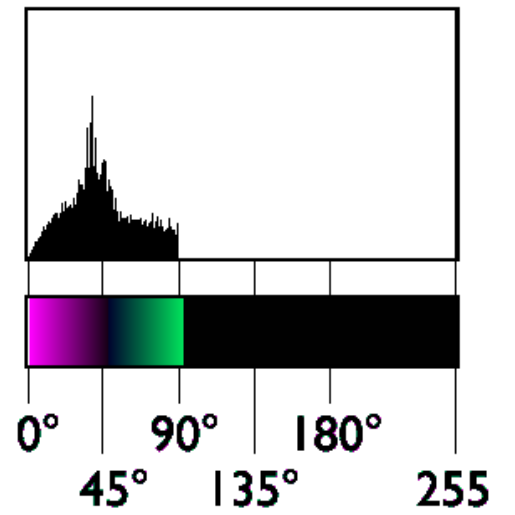
cip2



misorientations: internal reference directions



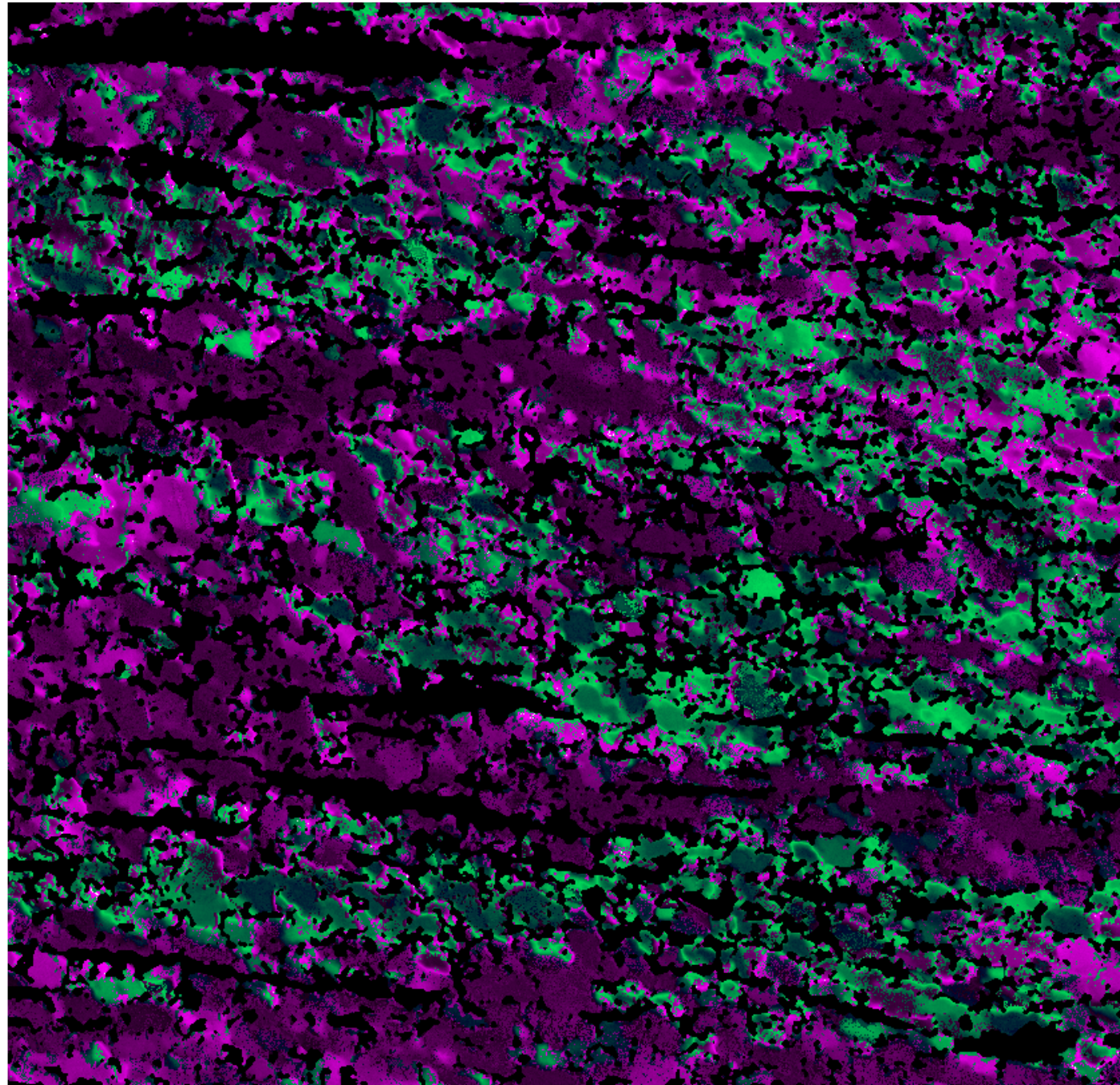
mis_160_038



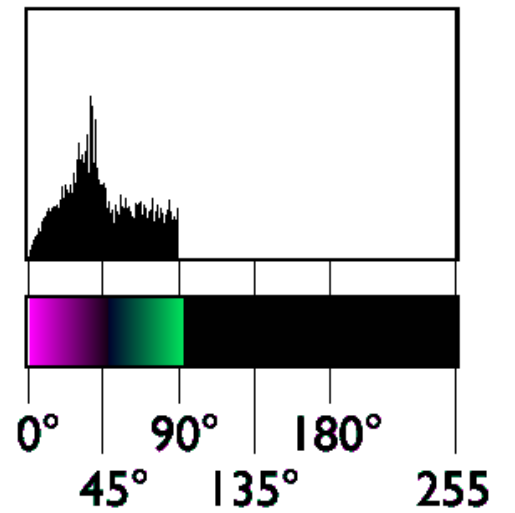
cip 4



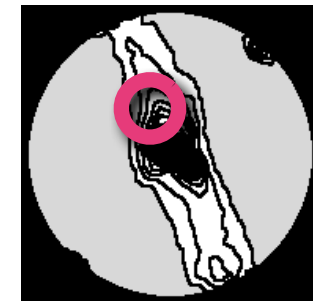
misorientations: internal reference directions

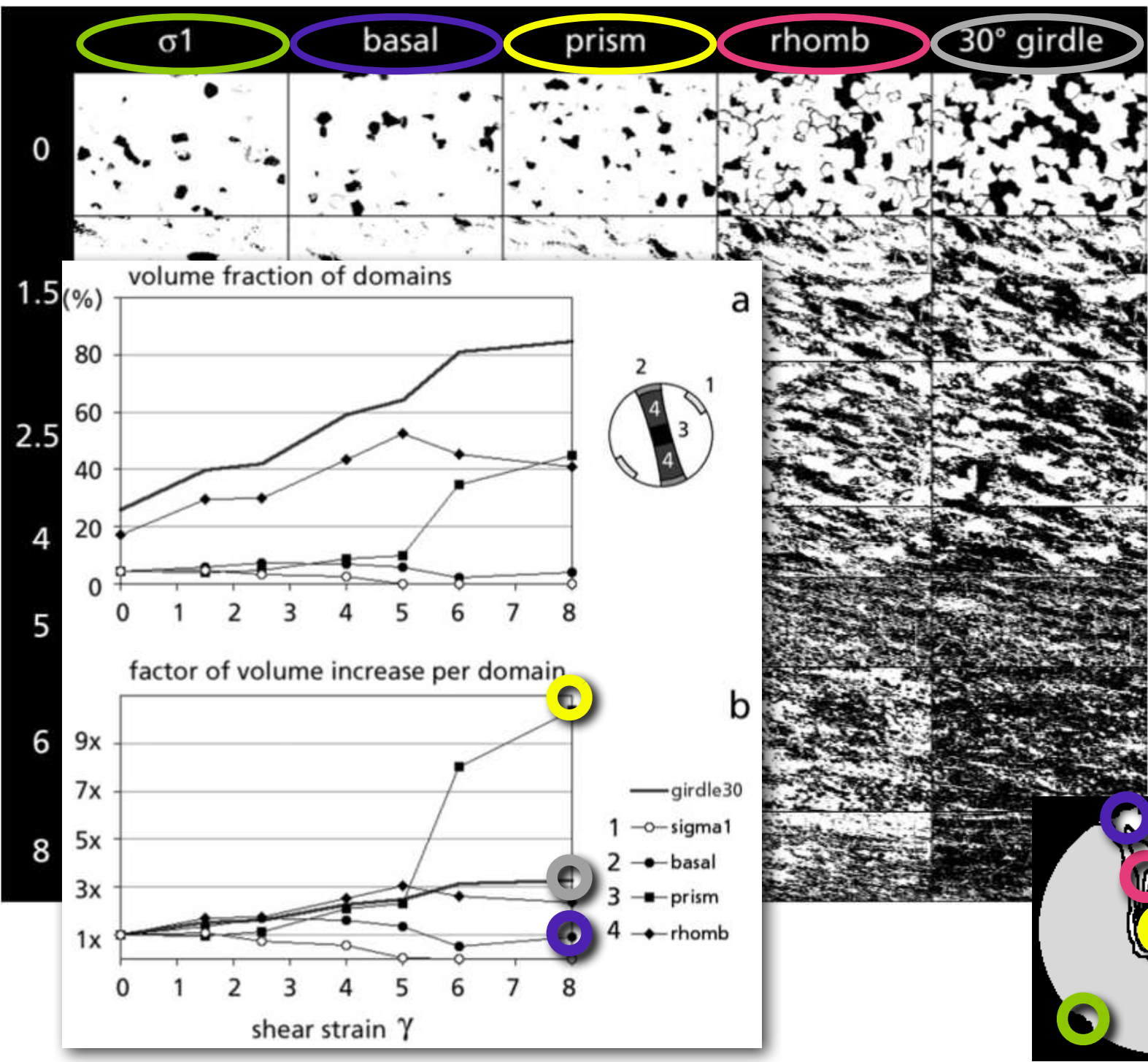


mis_160_142

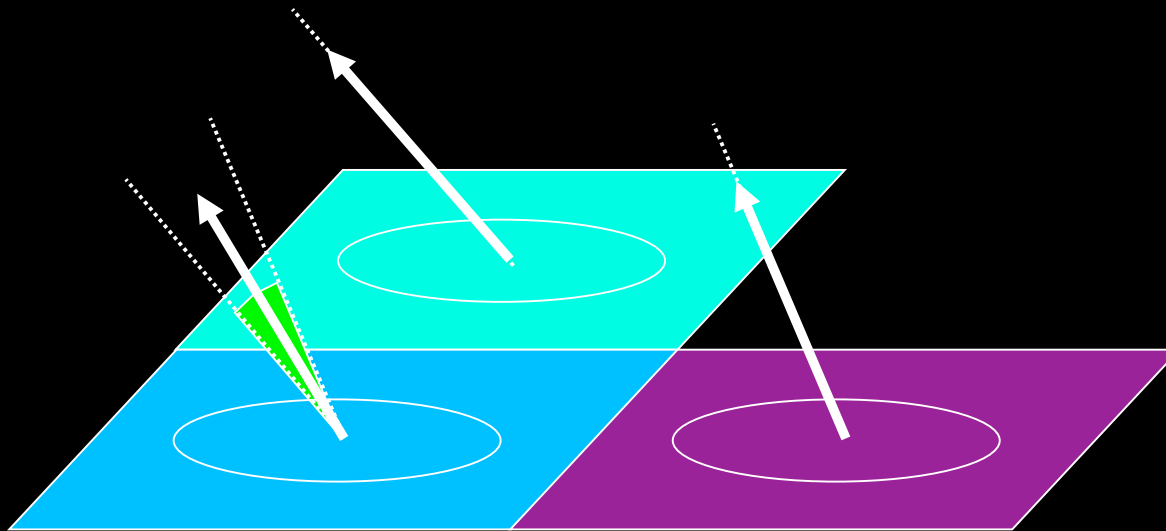


cip 4



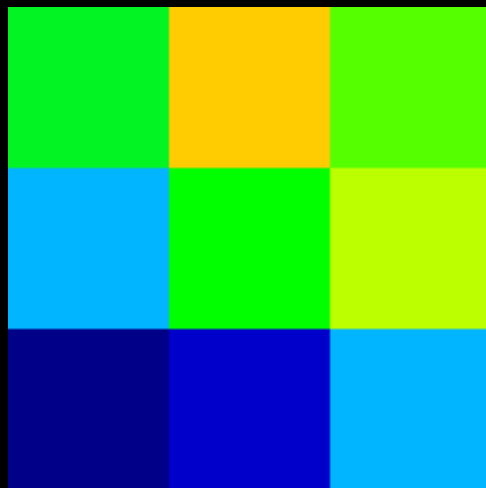


c-axis orientation gradient image (edge)



average angular
difference of optical
axis w/r to c-axis
orientation of
neighbouring pixels

I image plane
I-D CLUT



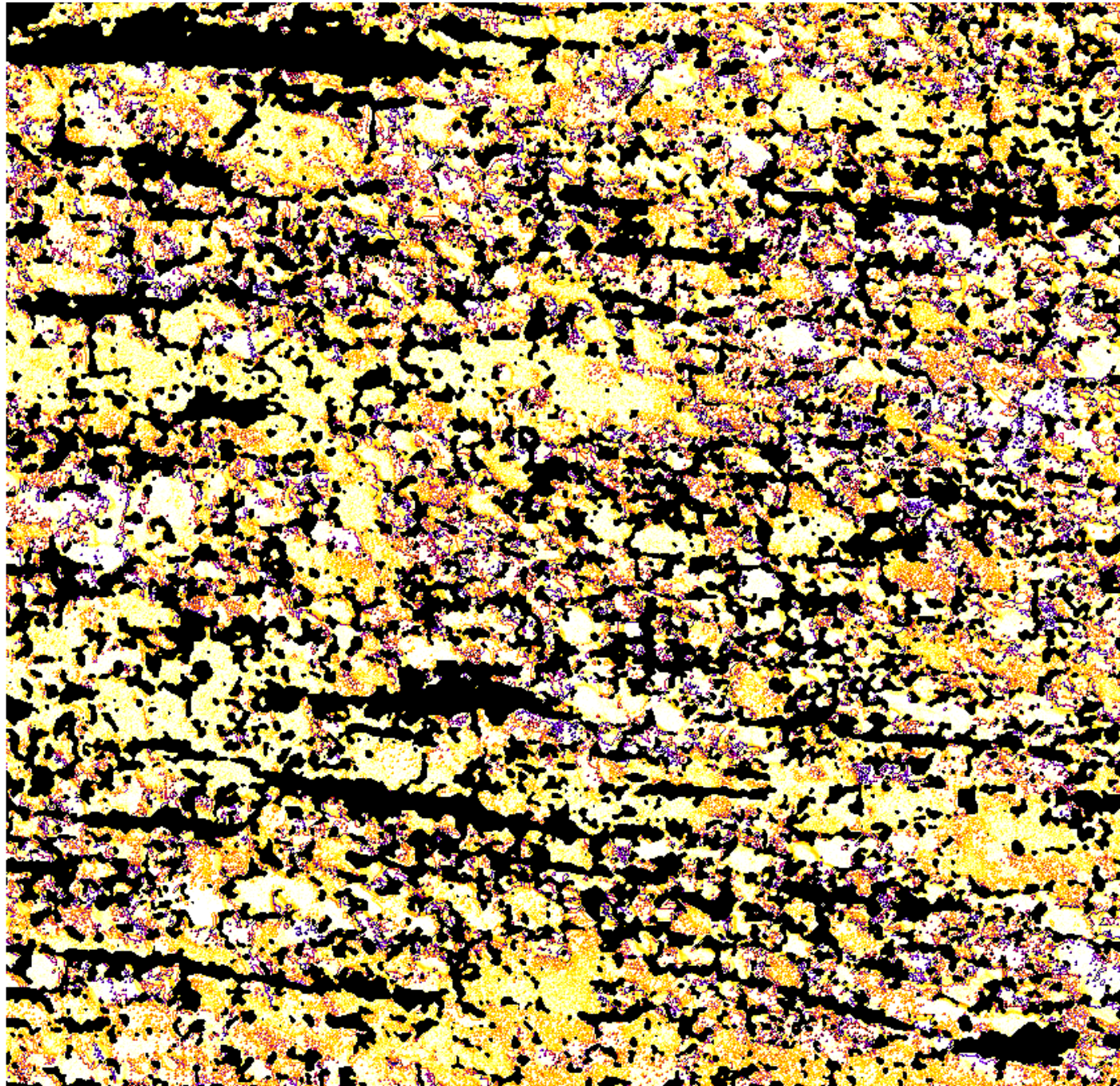
45	62	43
31	43	55
15	20	33



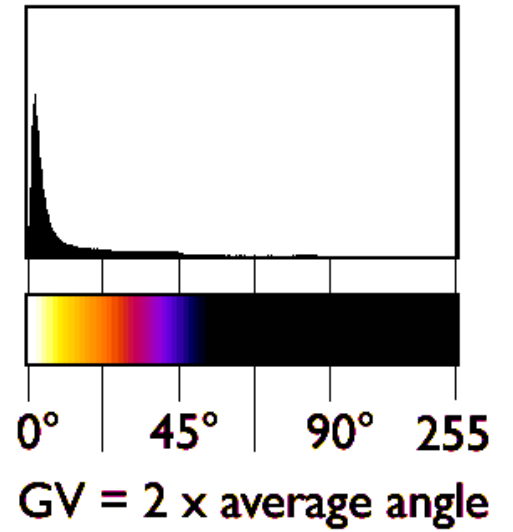
I-D CLUT

edg2 plane

orientation gradients

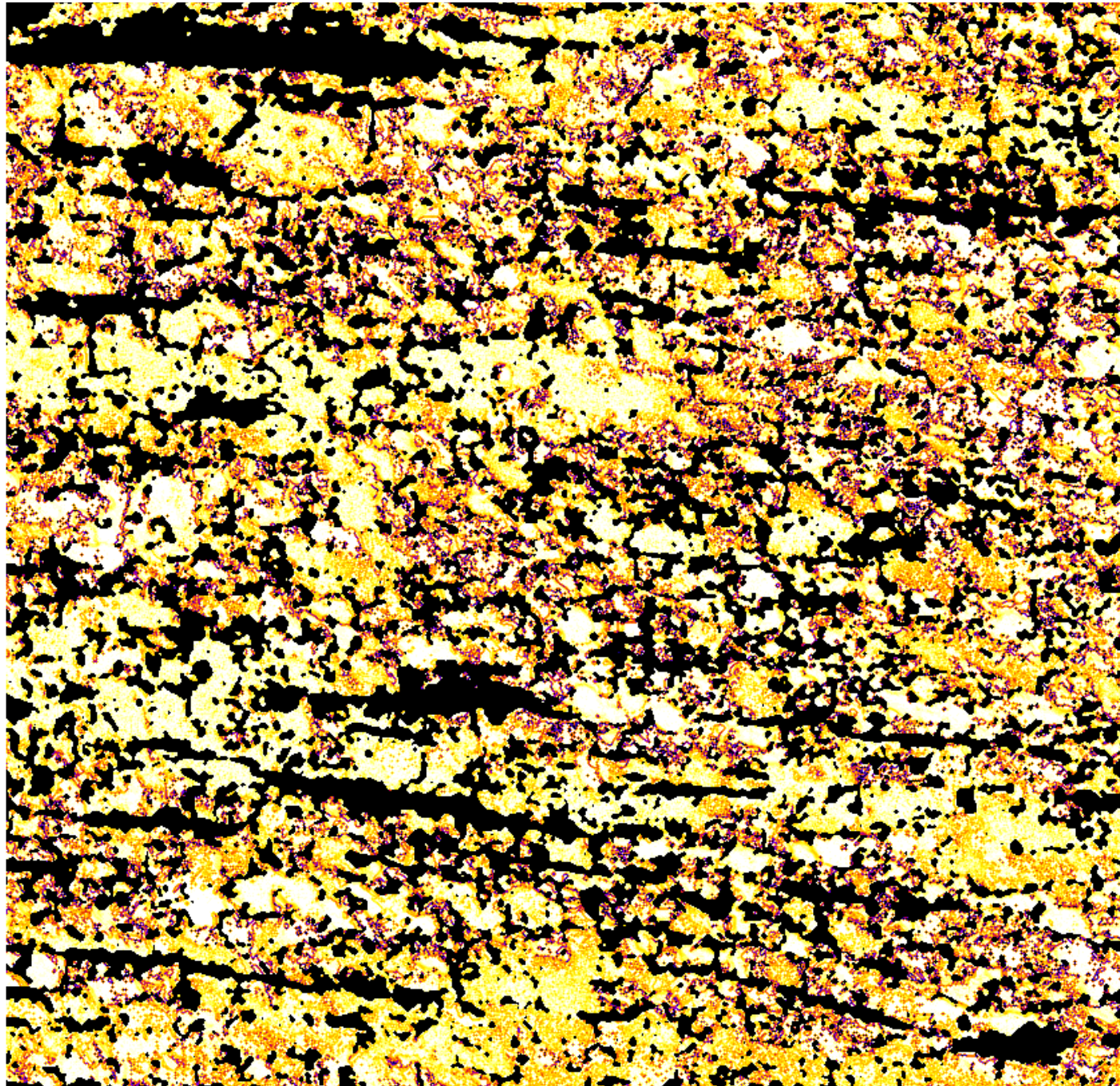


edge2s 

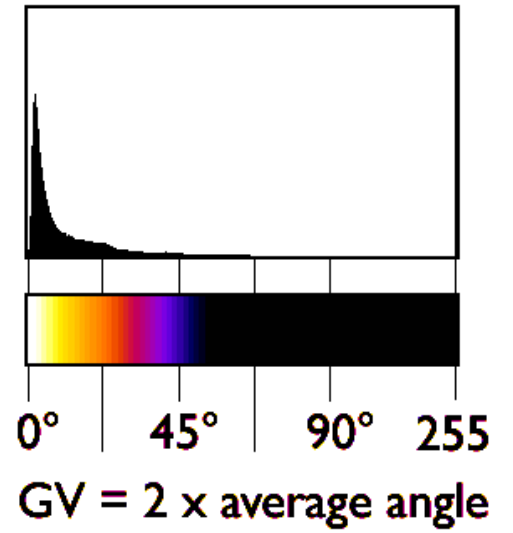


cip2

orientation gradients

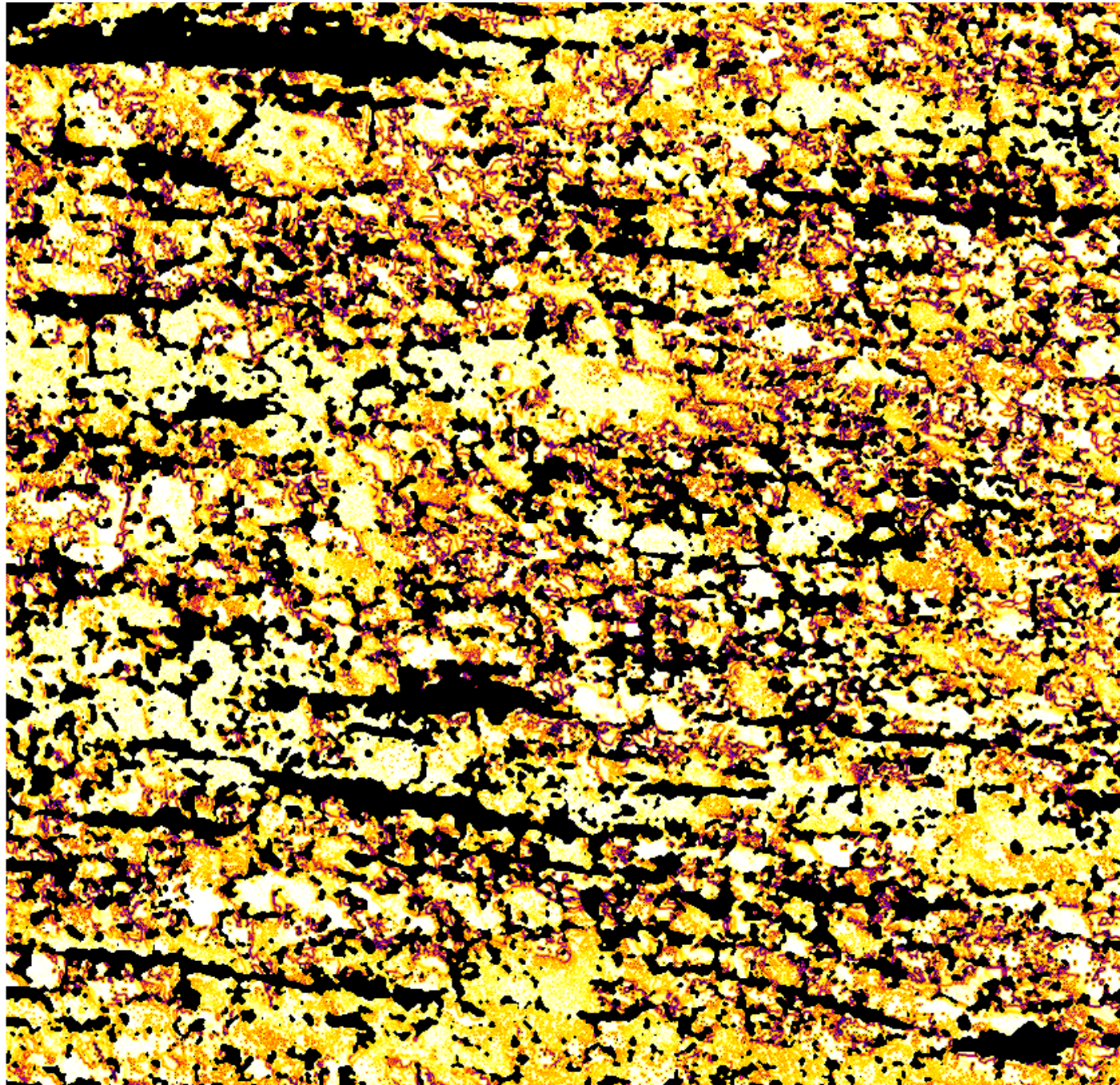


edge4a 

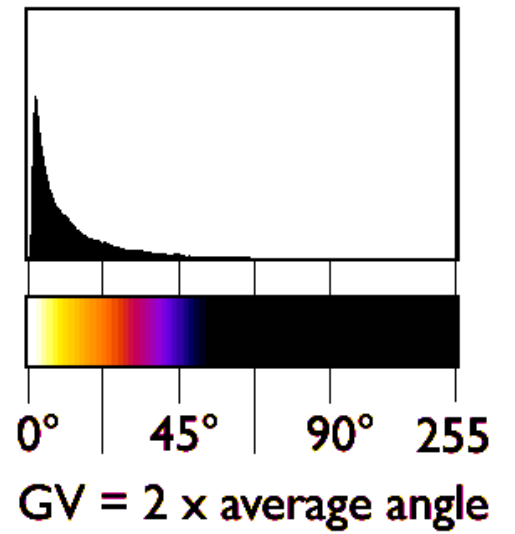


cip2

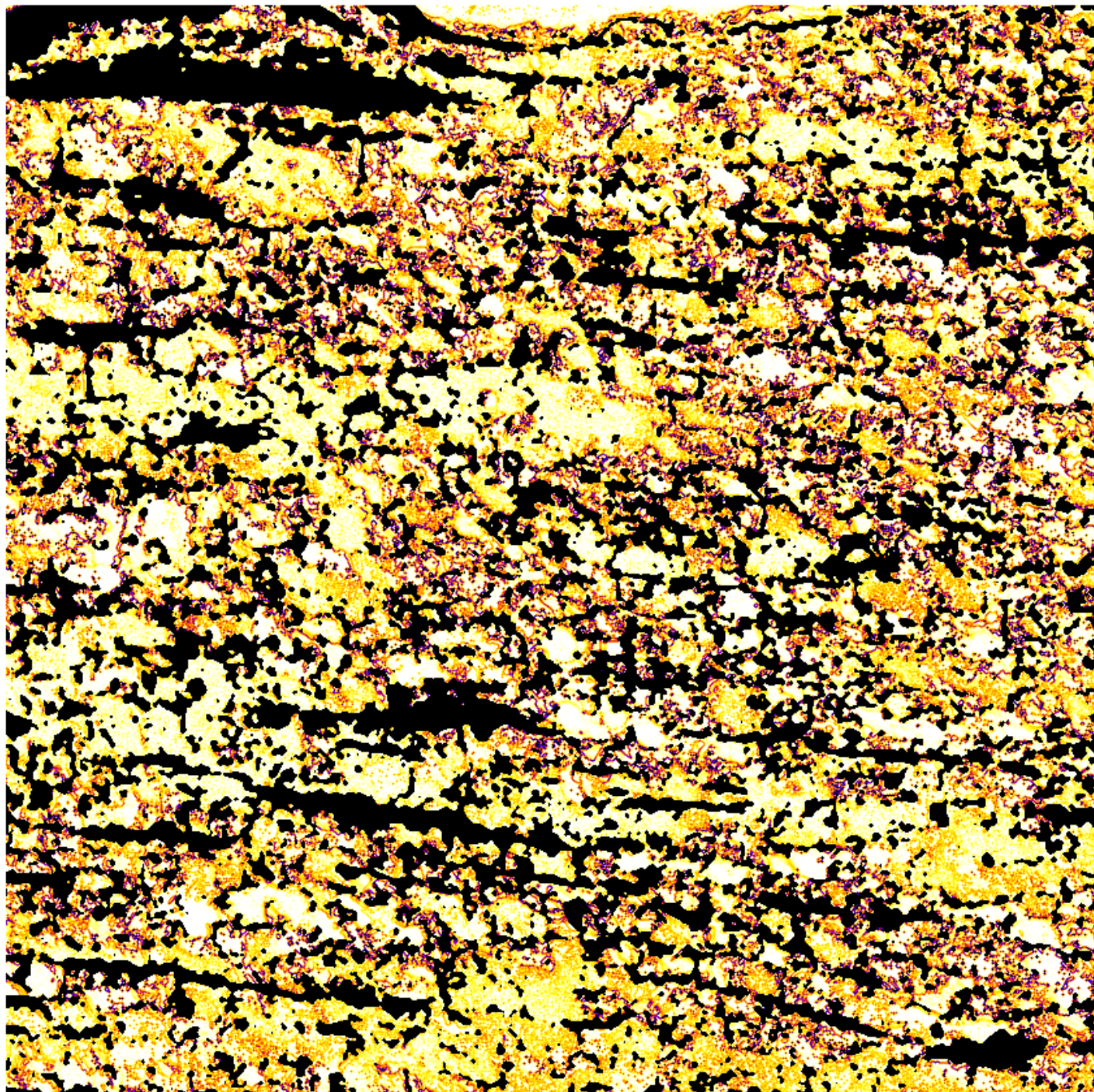
orientation gradients



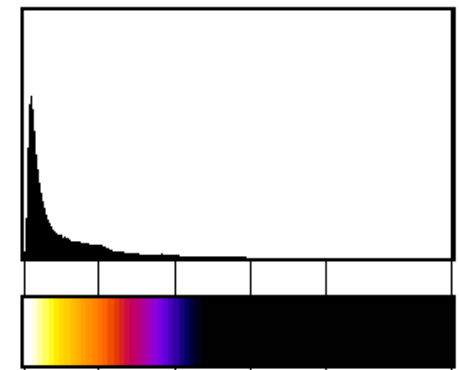
edge8a 



cip 4



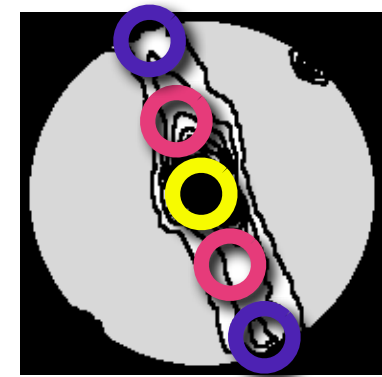
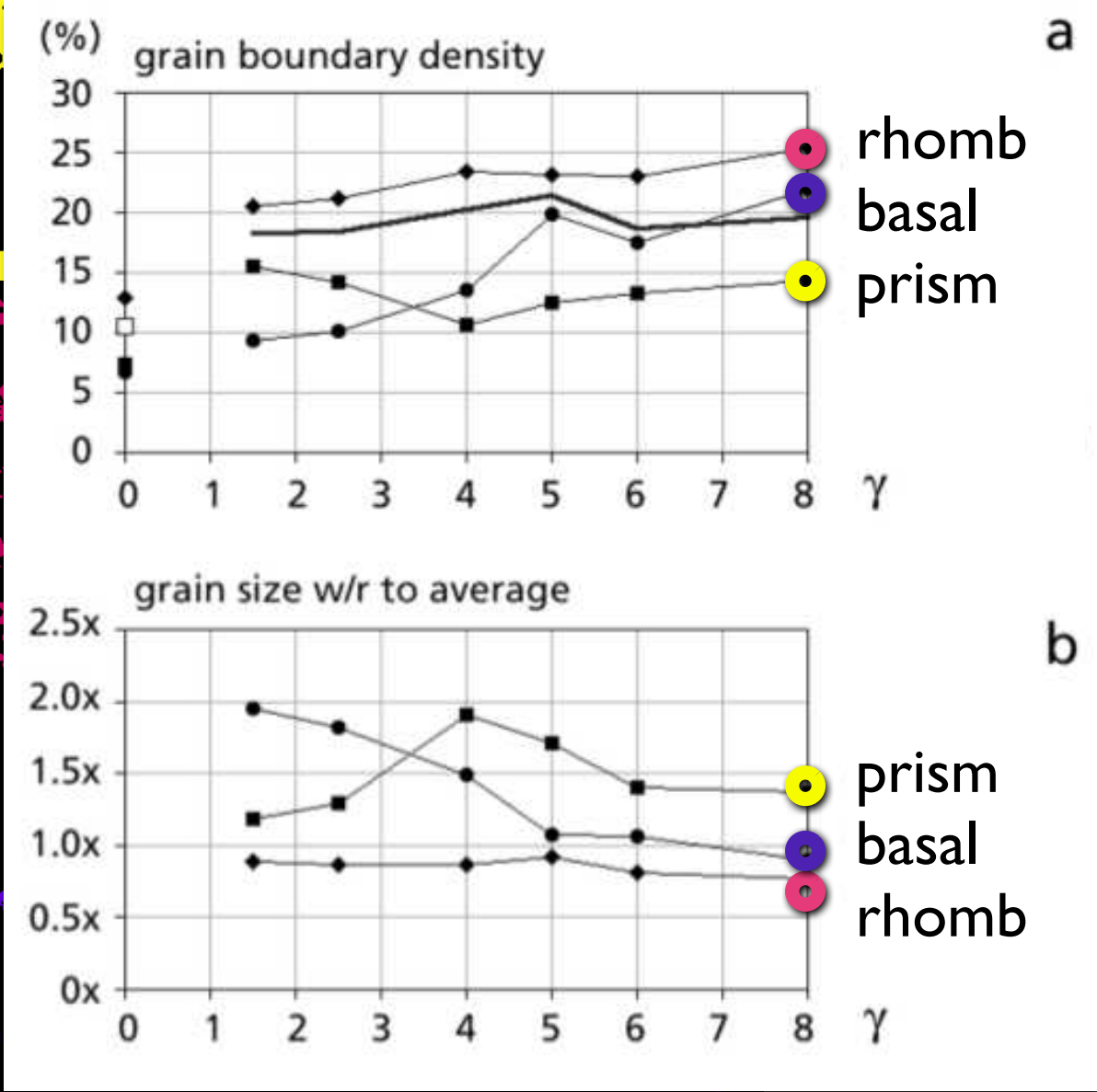
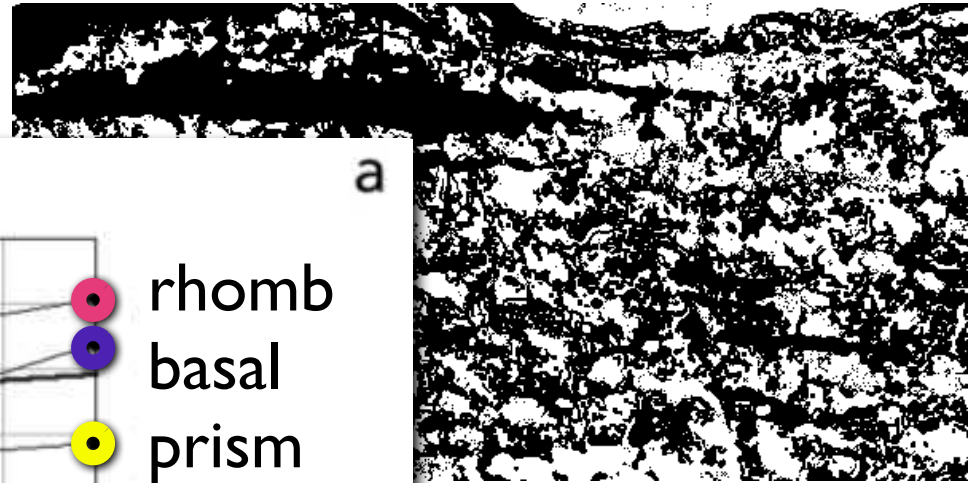
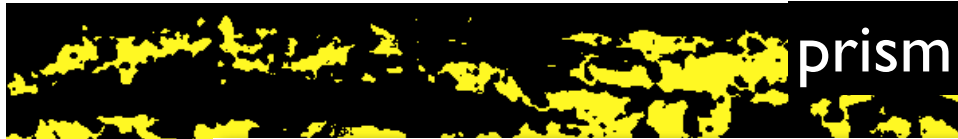
edge4a



0° 45° 90° 255

GV = 2 x average angle

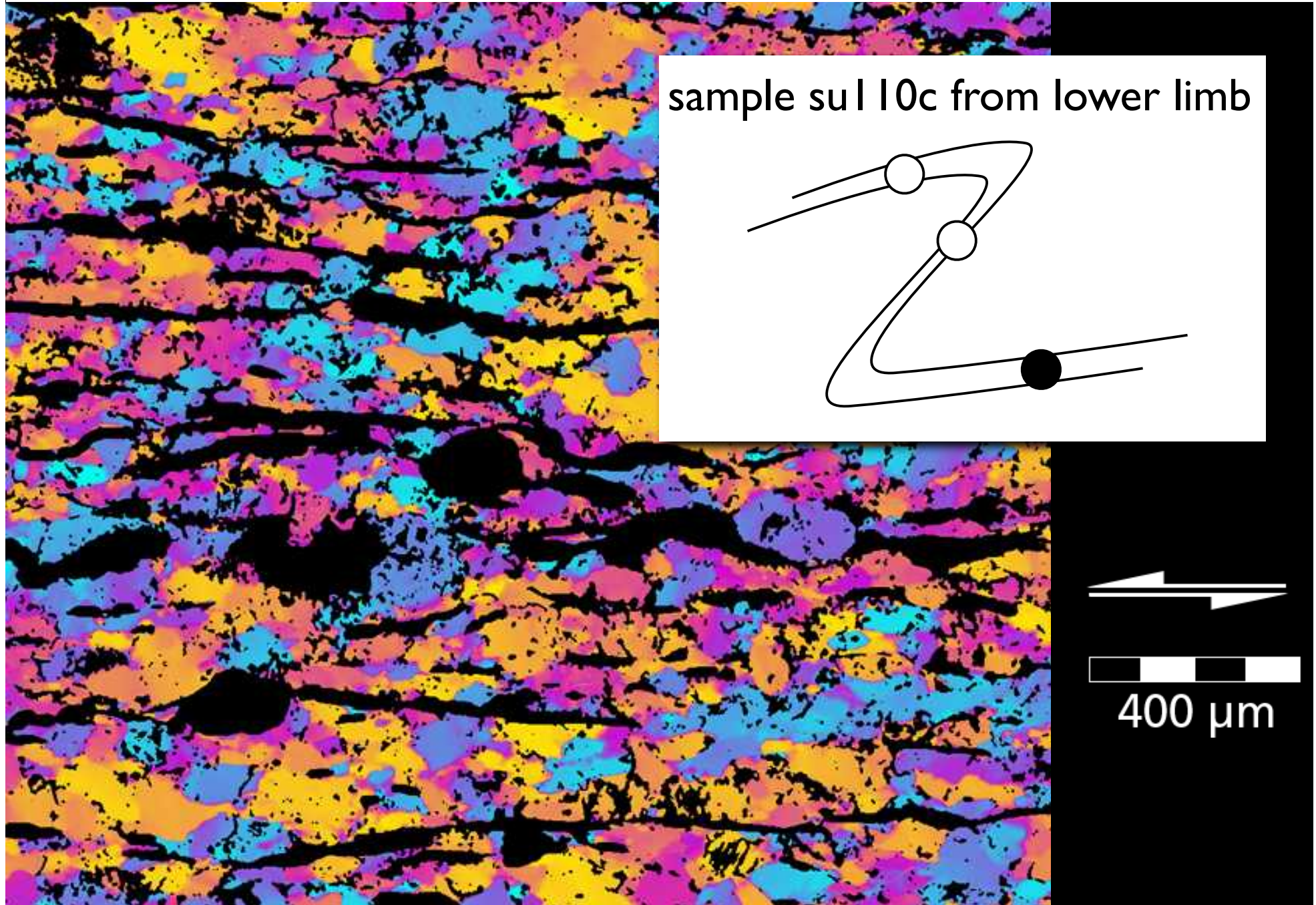
cip2



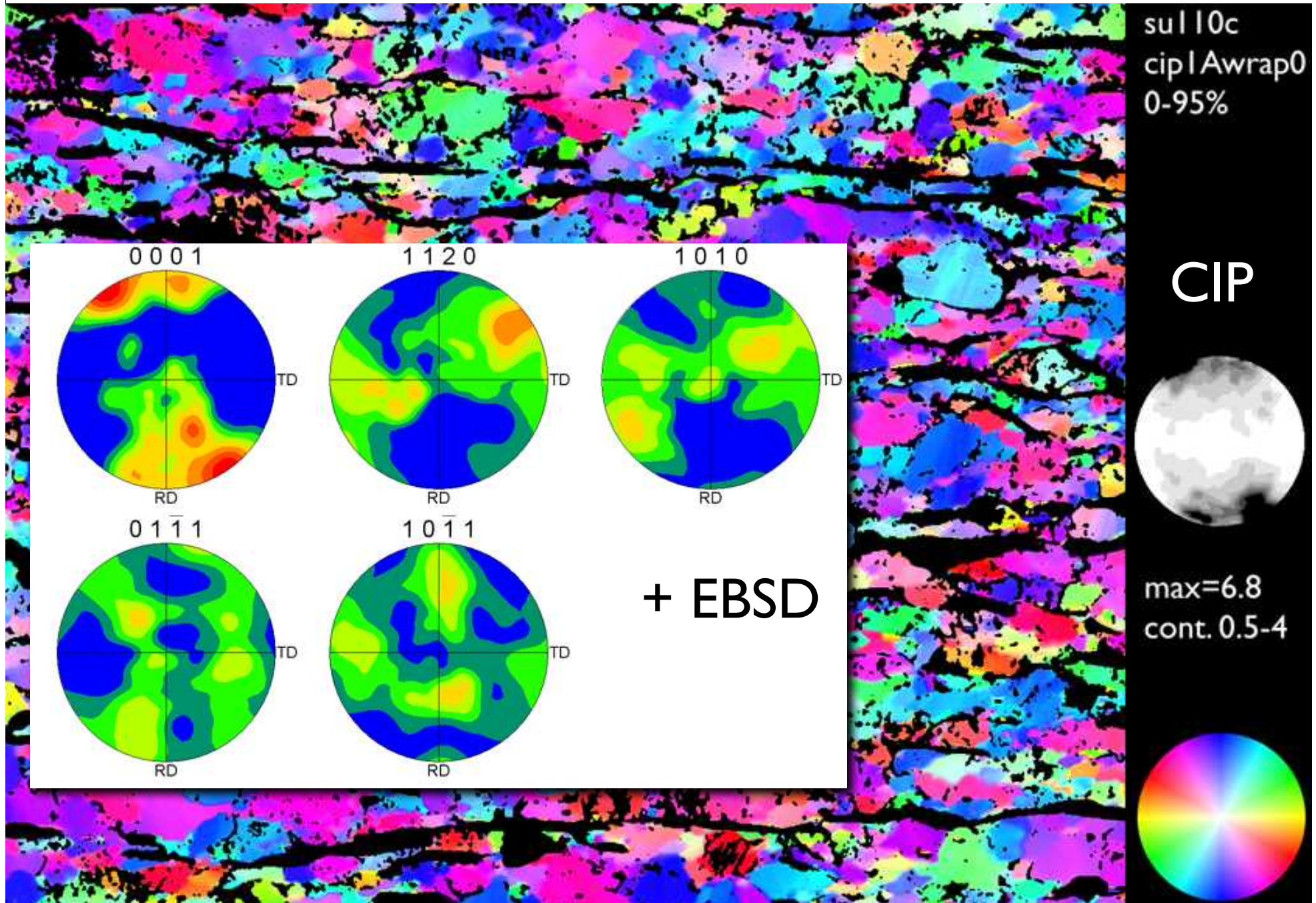
CIP - EBSD compare and contrast

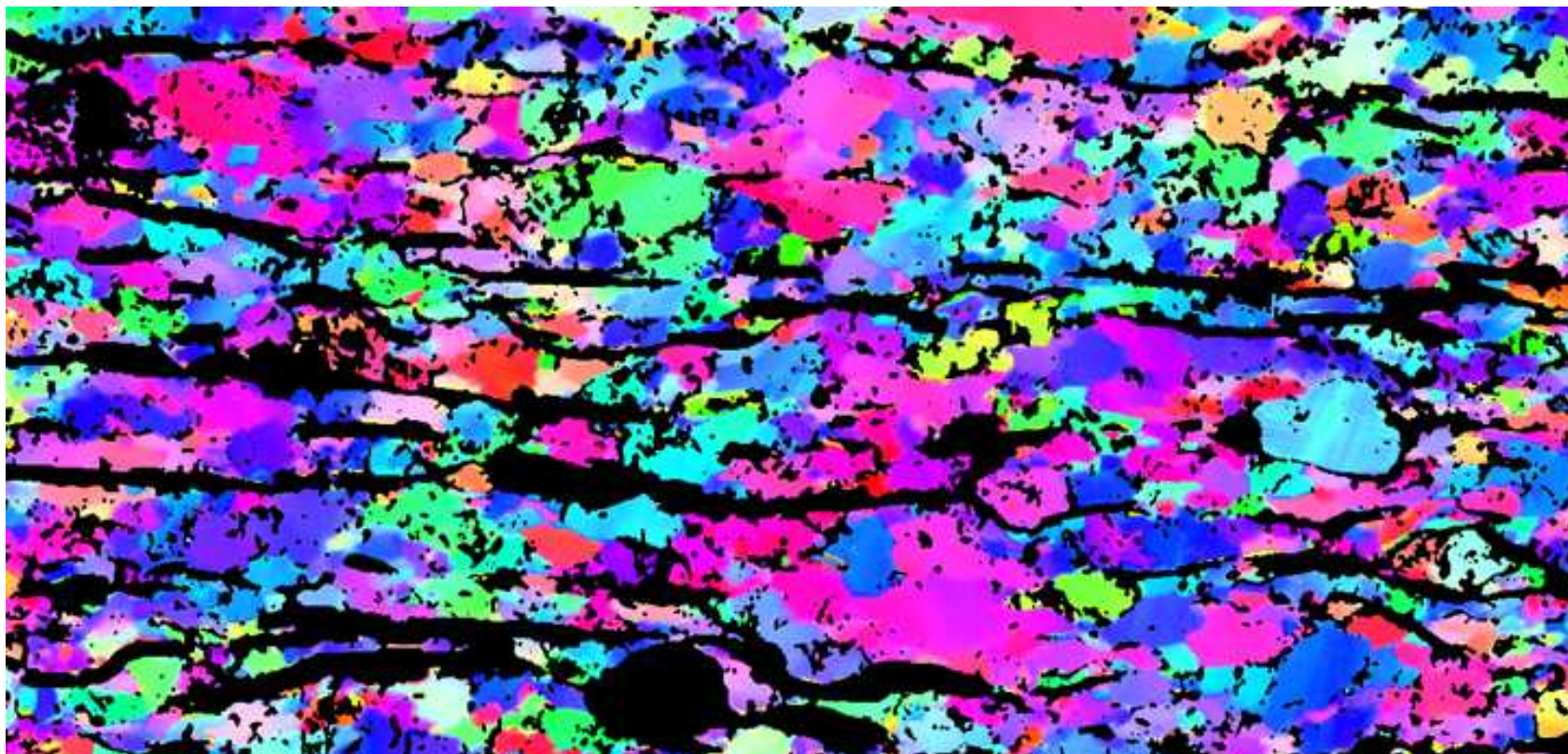
1. optical / orientation imaging (CIP / EBSD)
2. CIP - computer-integrated polarization microscopy
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Suretta mylonite: CPO around a minor fold



Suretta mylonite: CPO around a minor fold



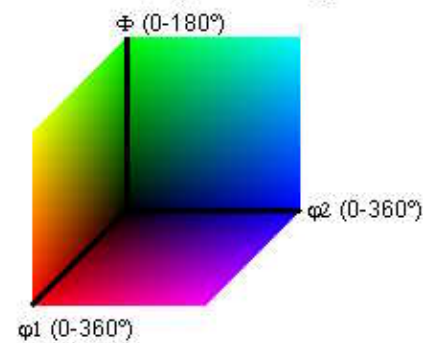


su l l 0c
cip l Awrap 0
0-95%

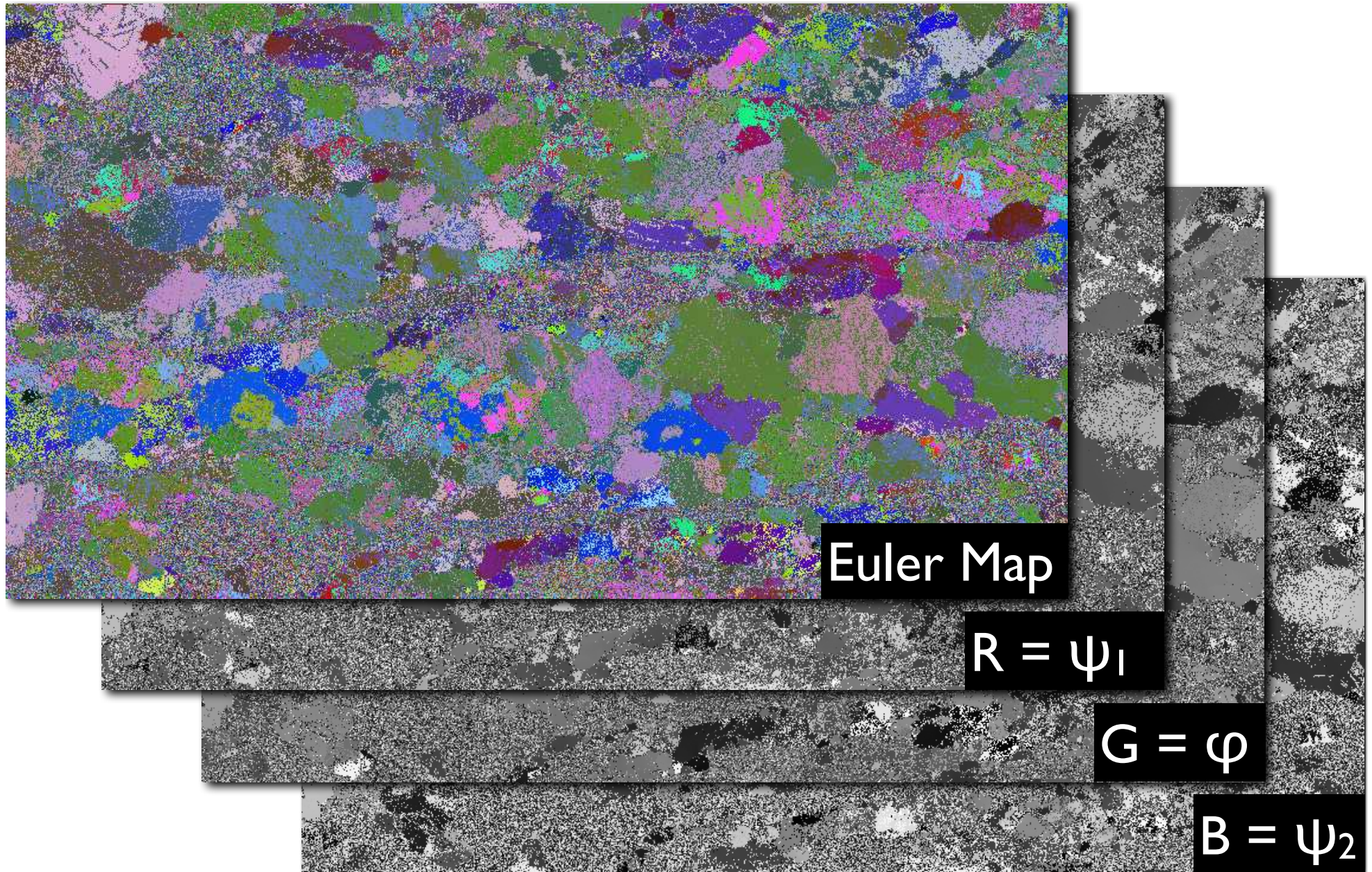
CIP

EBSD

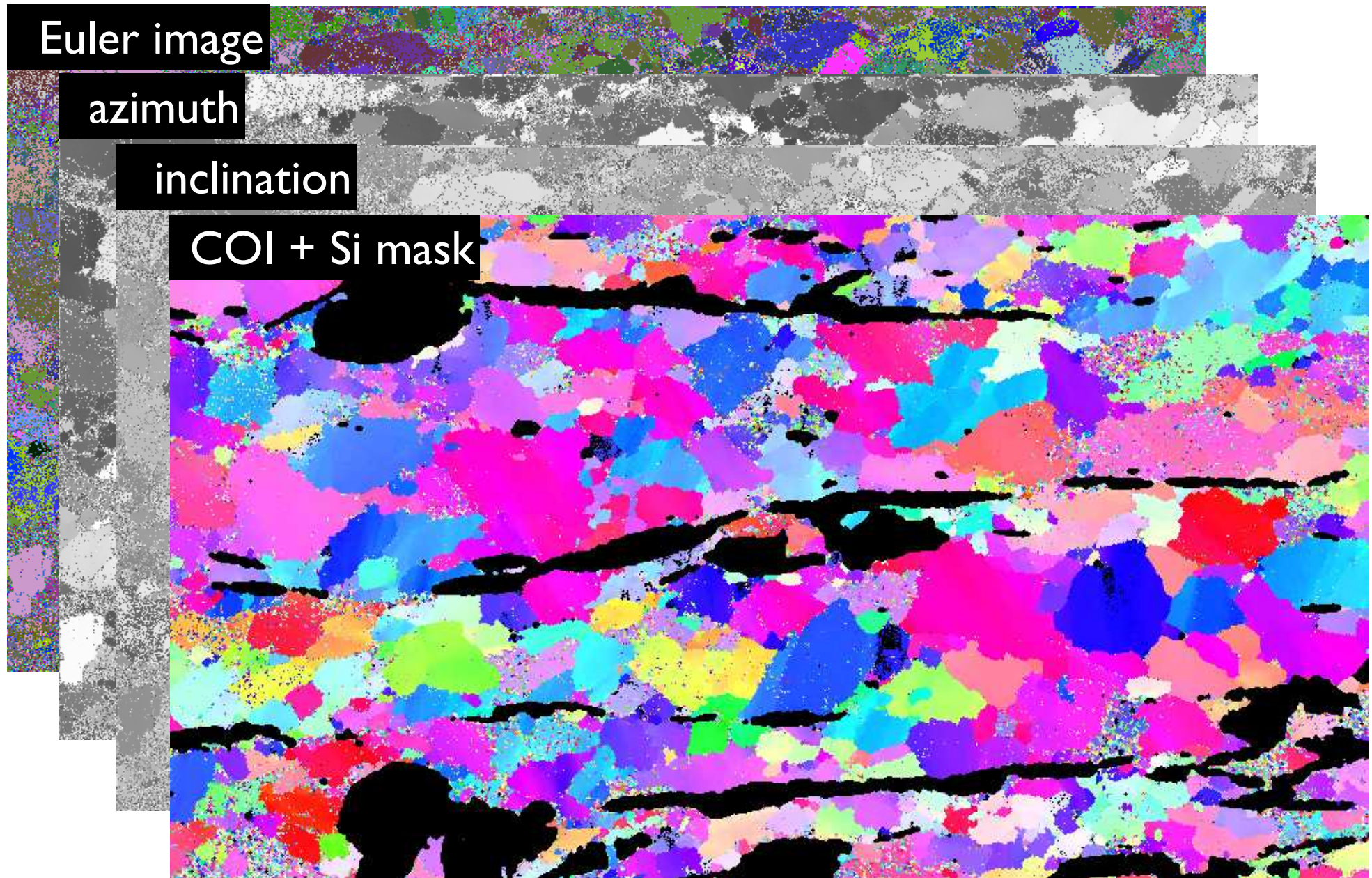
Color Coded Map Type: Euler Angle RGB



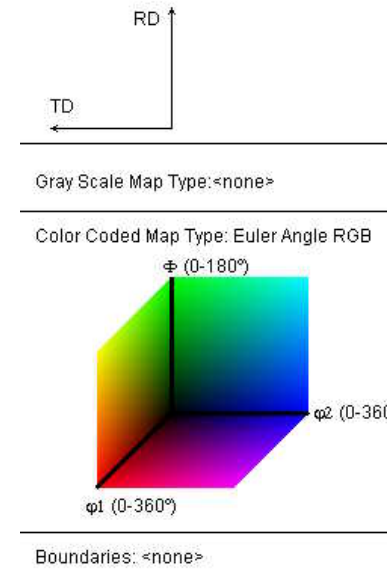
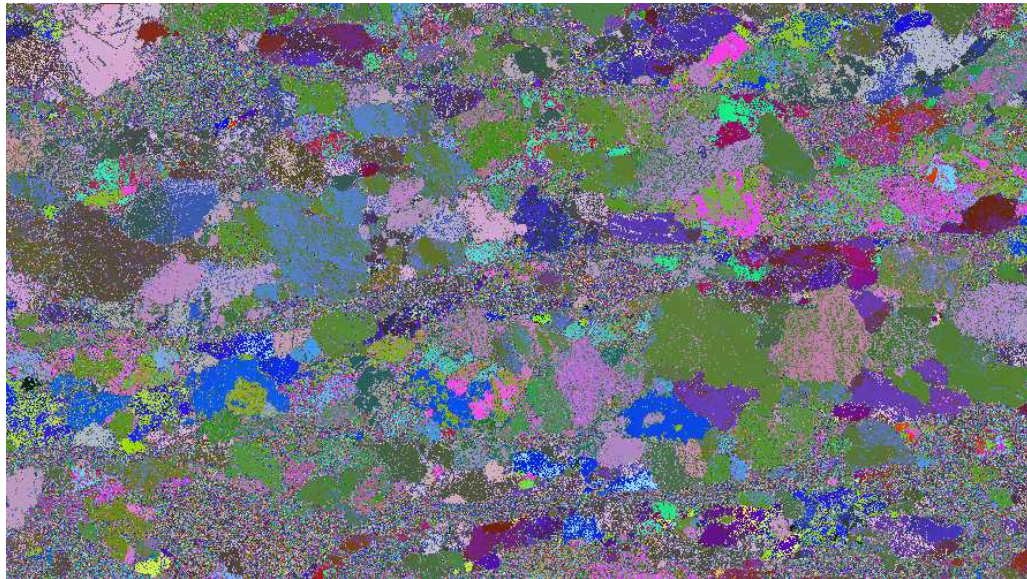
"Euler map" from EBSD



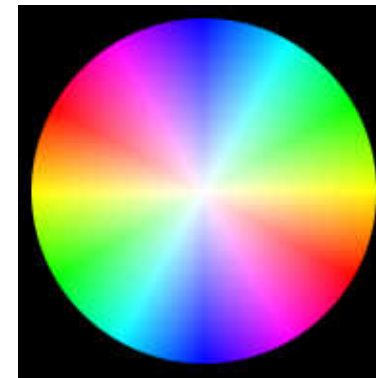
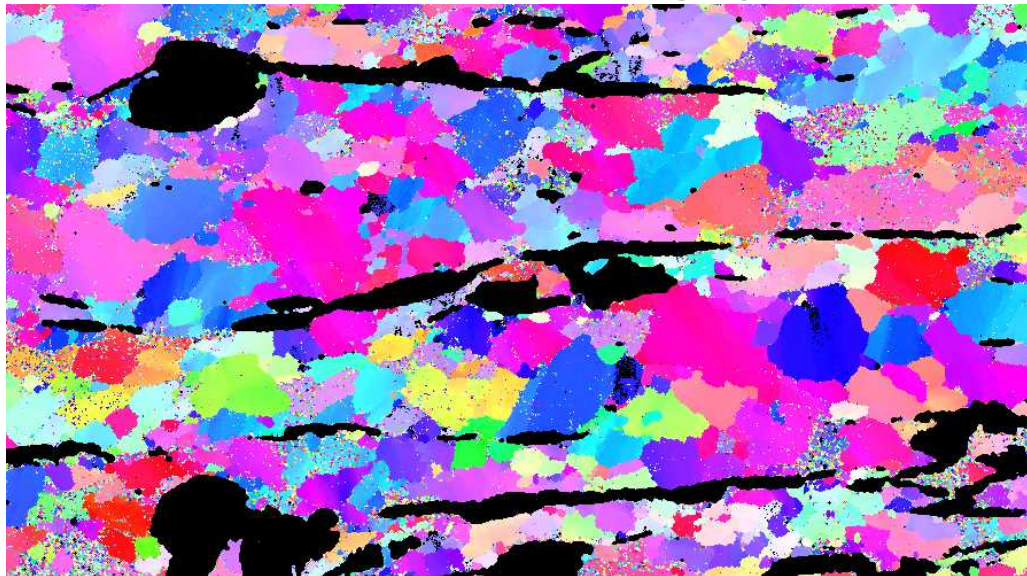
Euler image > c-axis azi / inc > orientation image



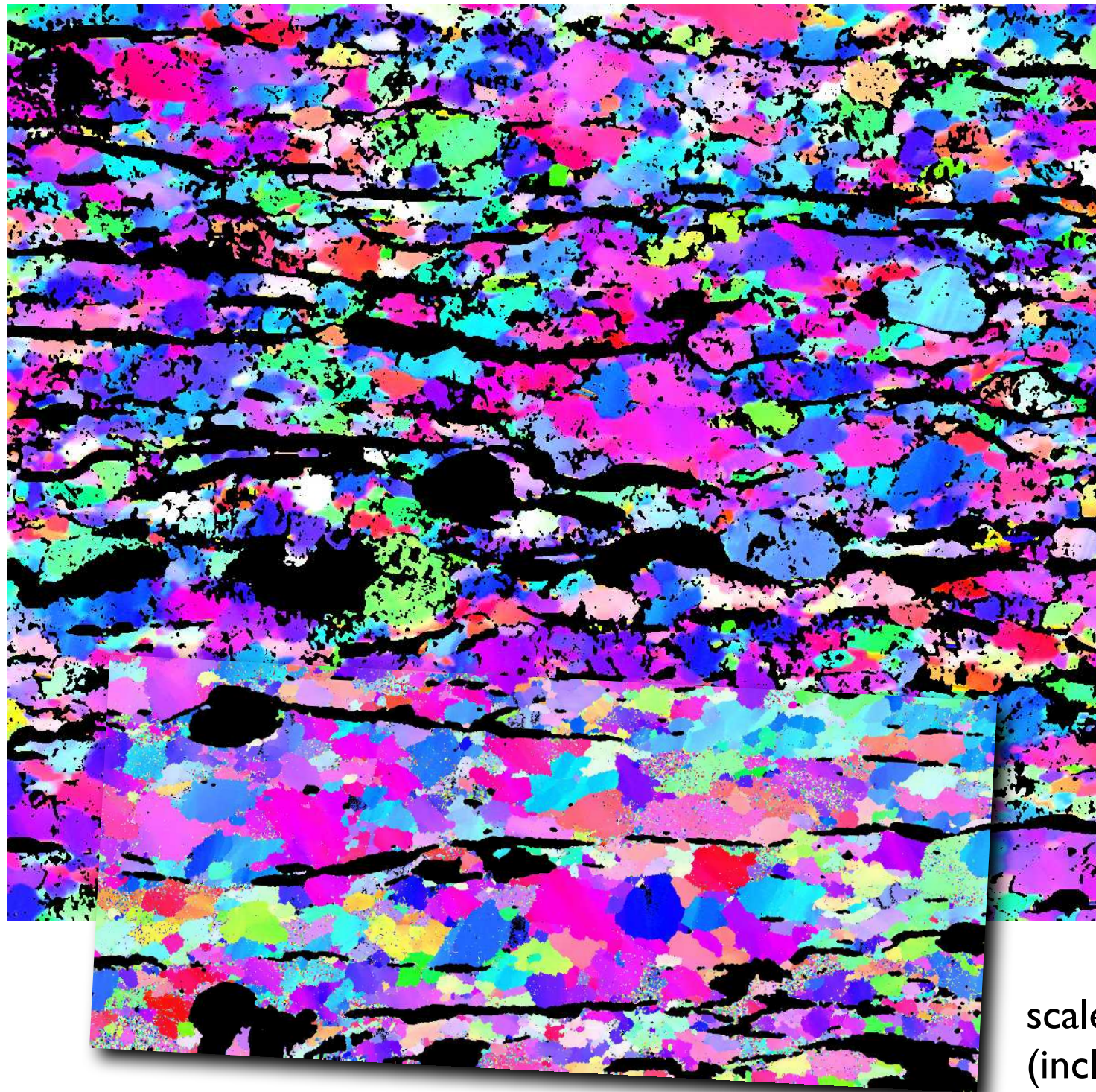
EBSD: Euler angle coloring



EBSD: c-axis coloring (CIP coloring)



CIP



su110c



400 μm



max = 5.1
0.5 - 4.0



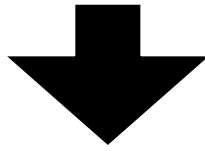
EBSD

scale / rotate
(incl. CLUT)

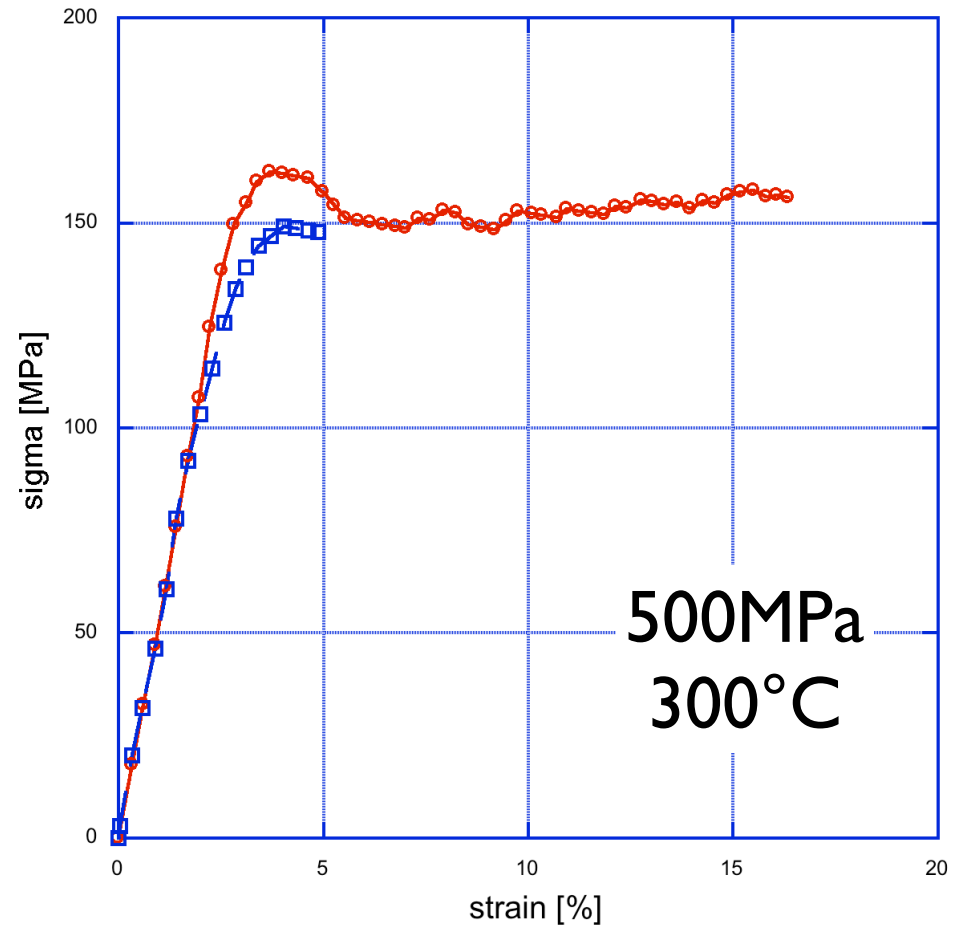
seeing $\langle a \rangle$ axes

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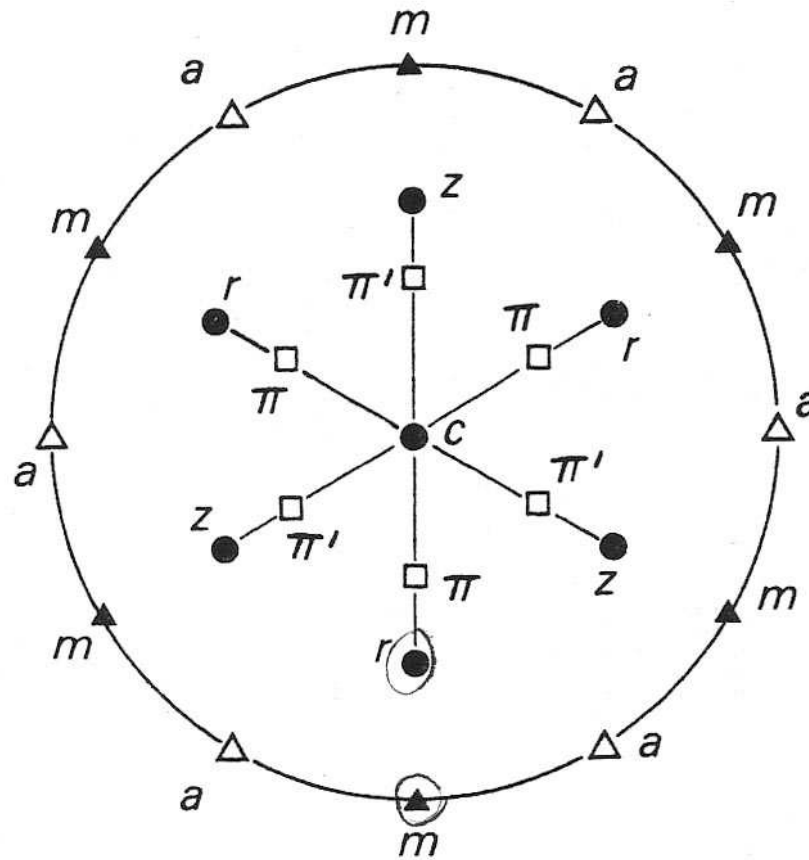
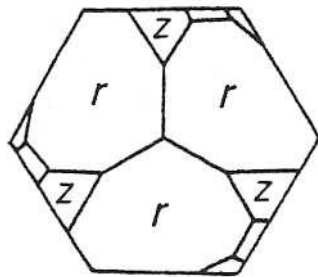
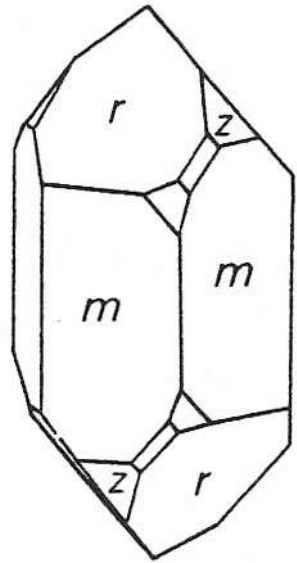
experimental deformation of quartz single crystal



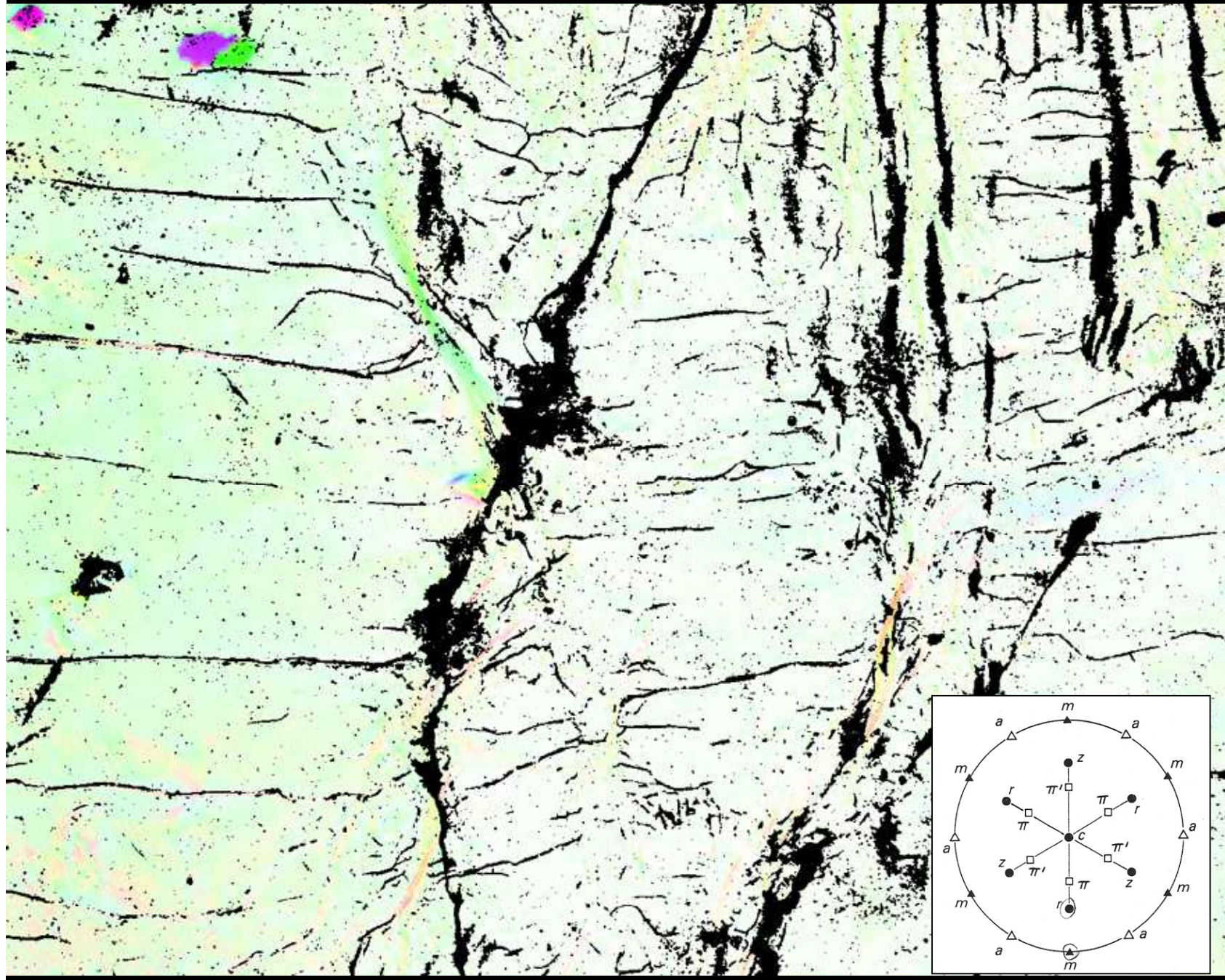
qtz | 44



quartz



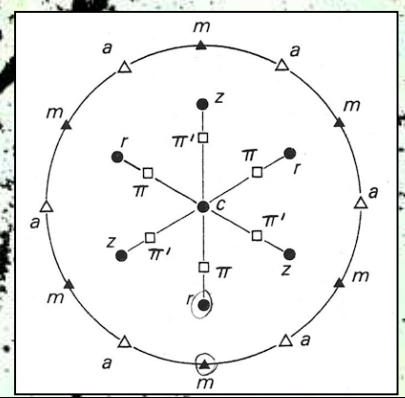
experimental deformation of quartz single crystal: CIP



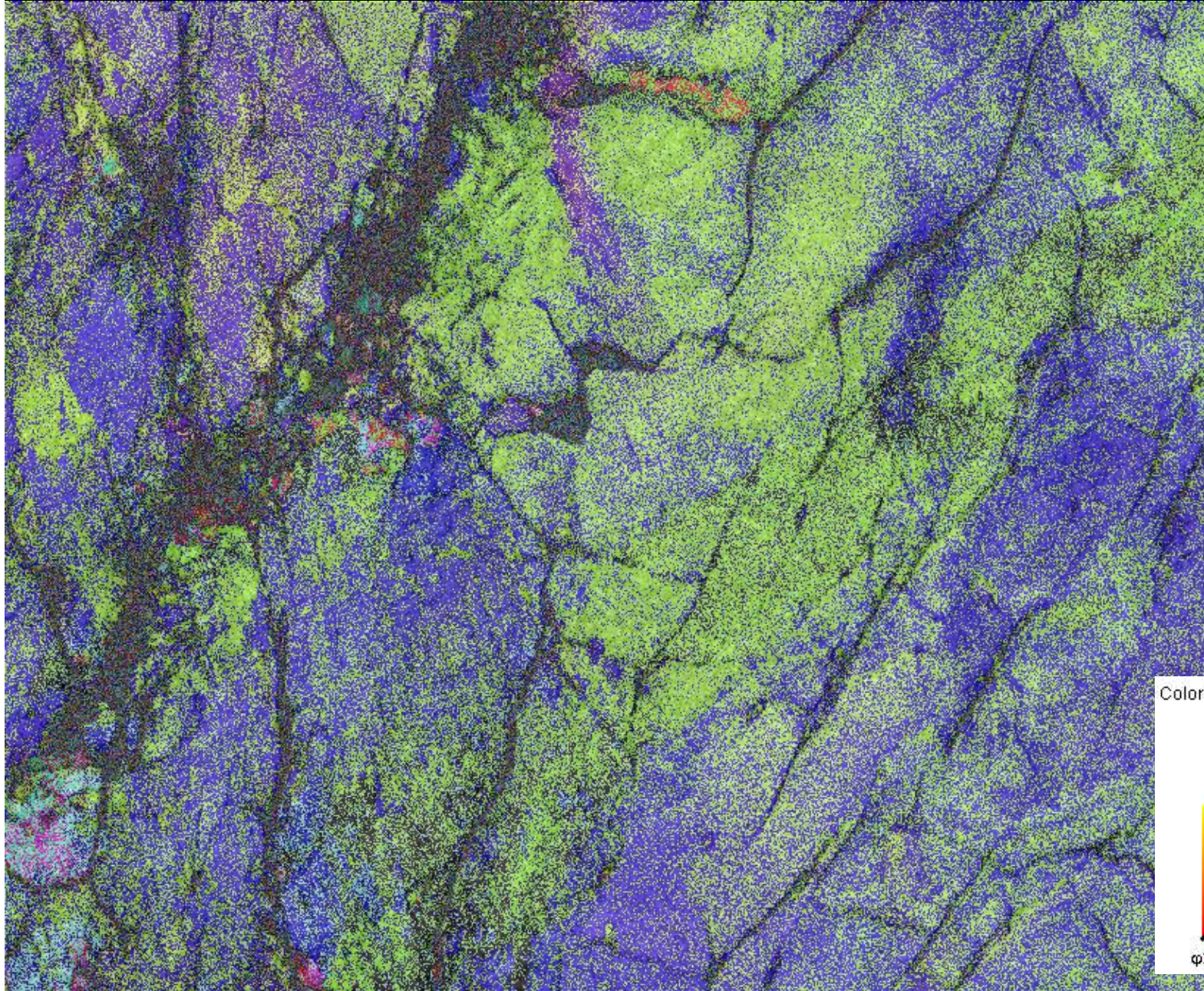
qtz | 44
cip | Awrap0
>5 - 100%



max=53.2
cont. 1 - 8



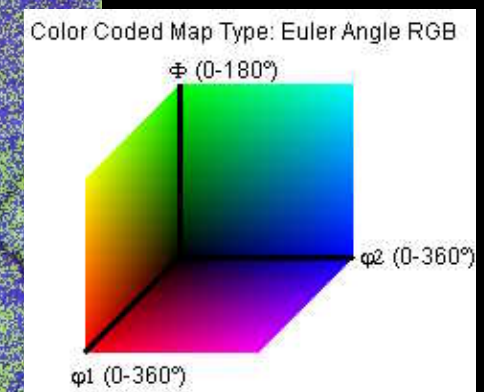
EBSD: Euler image RGB =



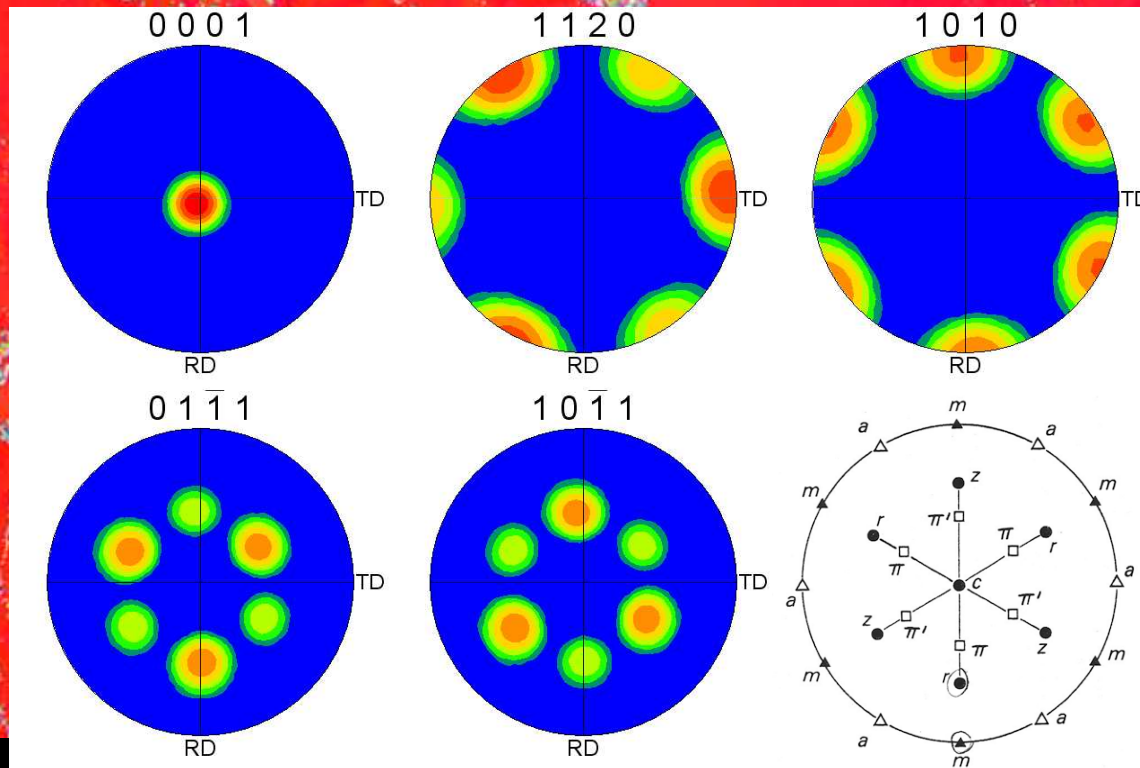
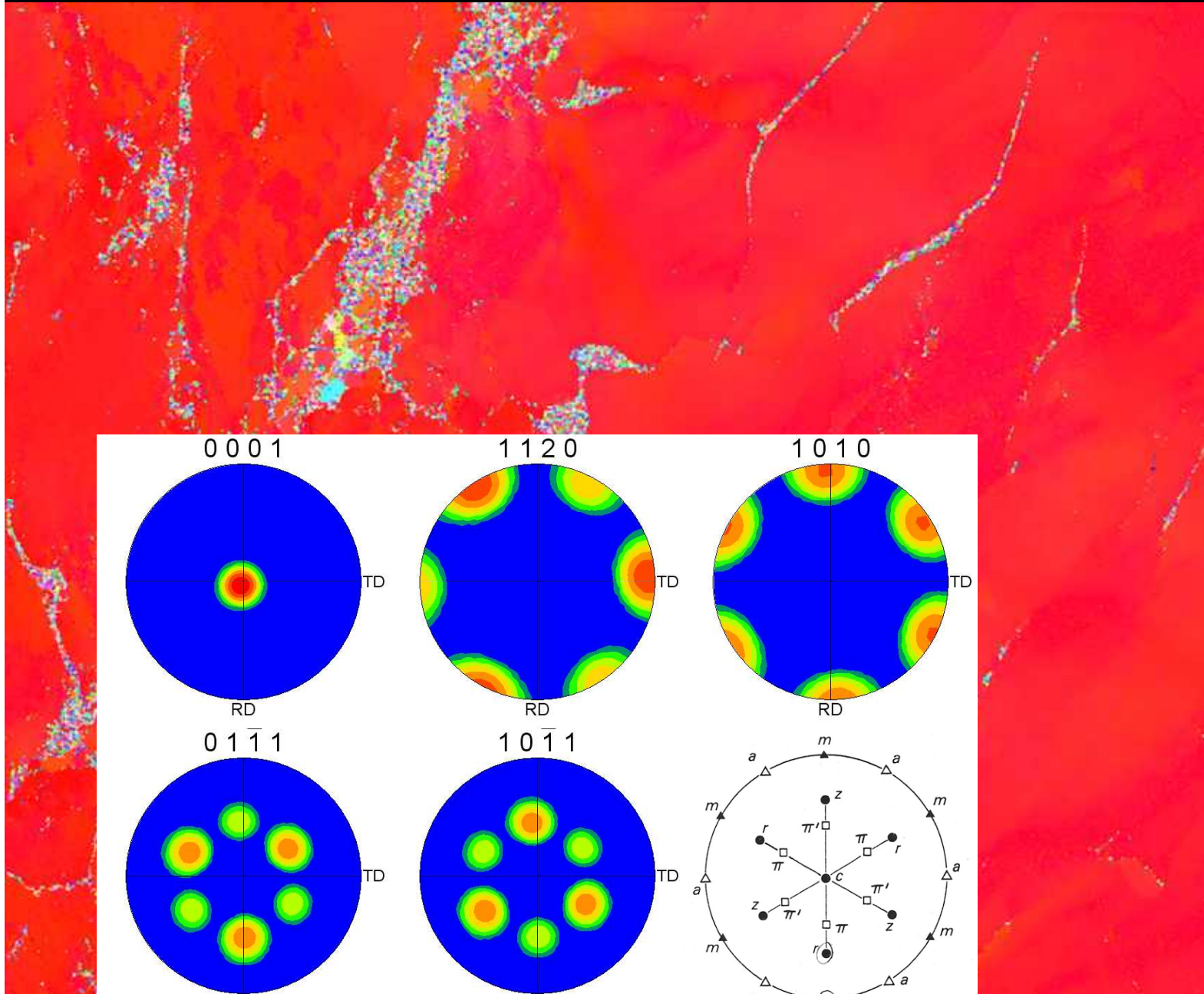
$$R = \psi_1$$

$$G = \varphi$$

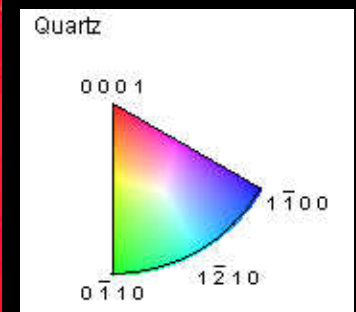
$$B = \psi_2$$



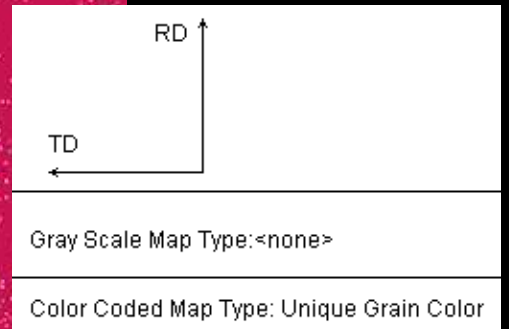
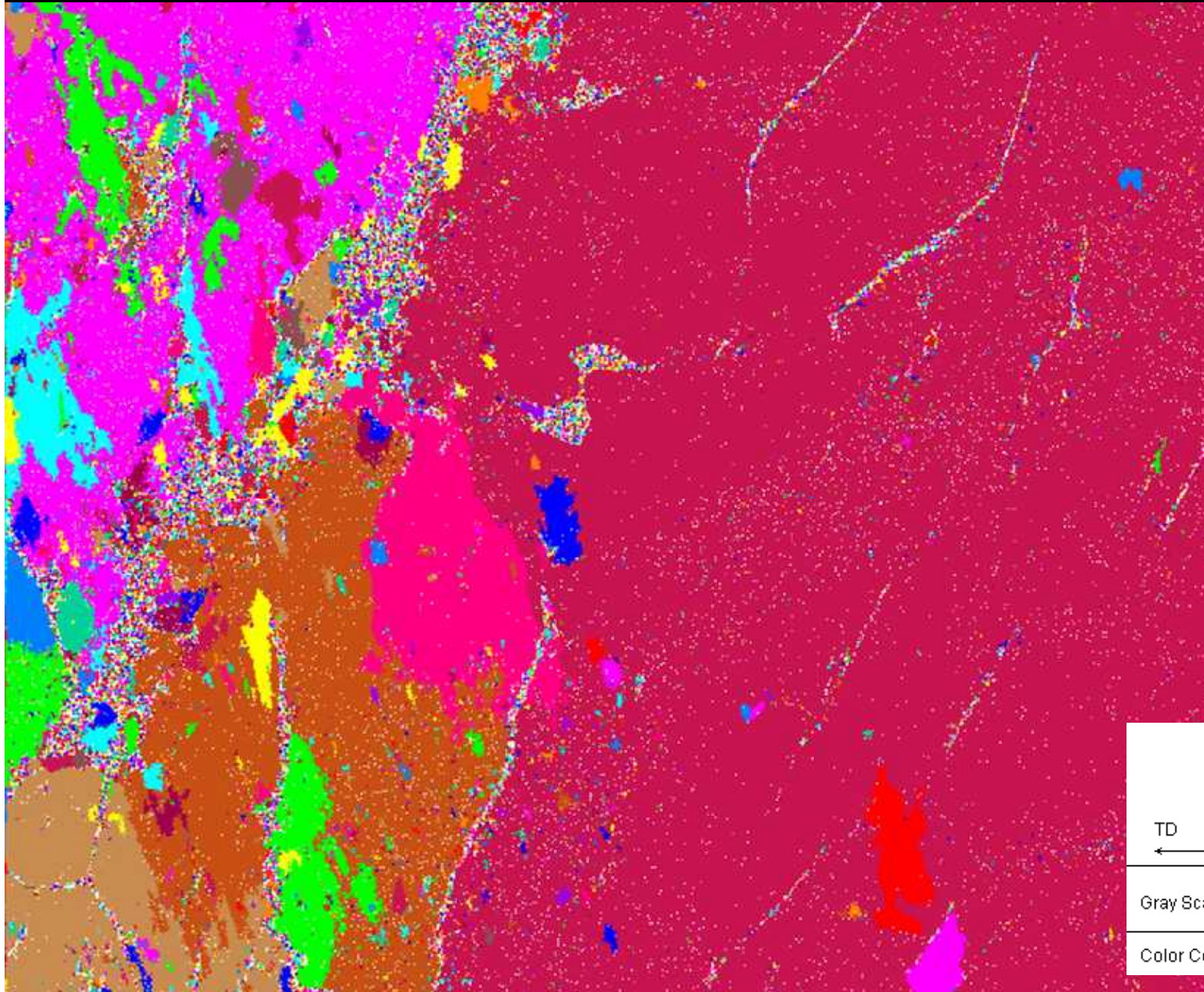
inverse pole figure coloring

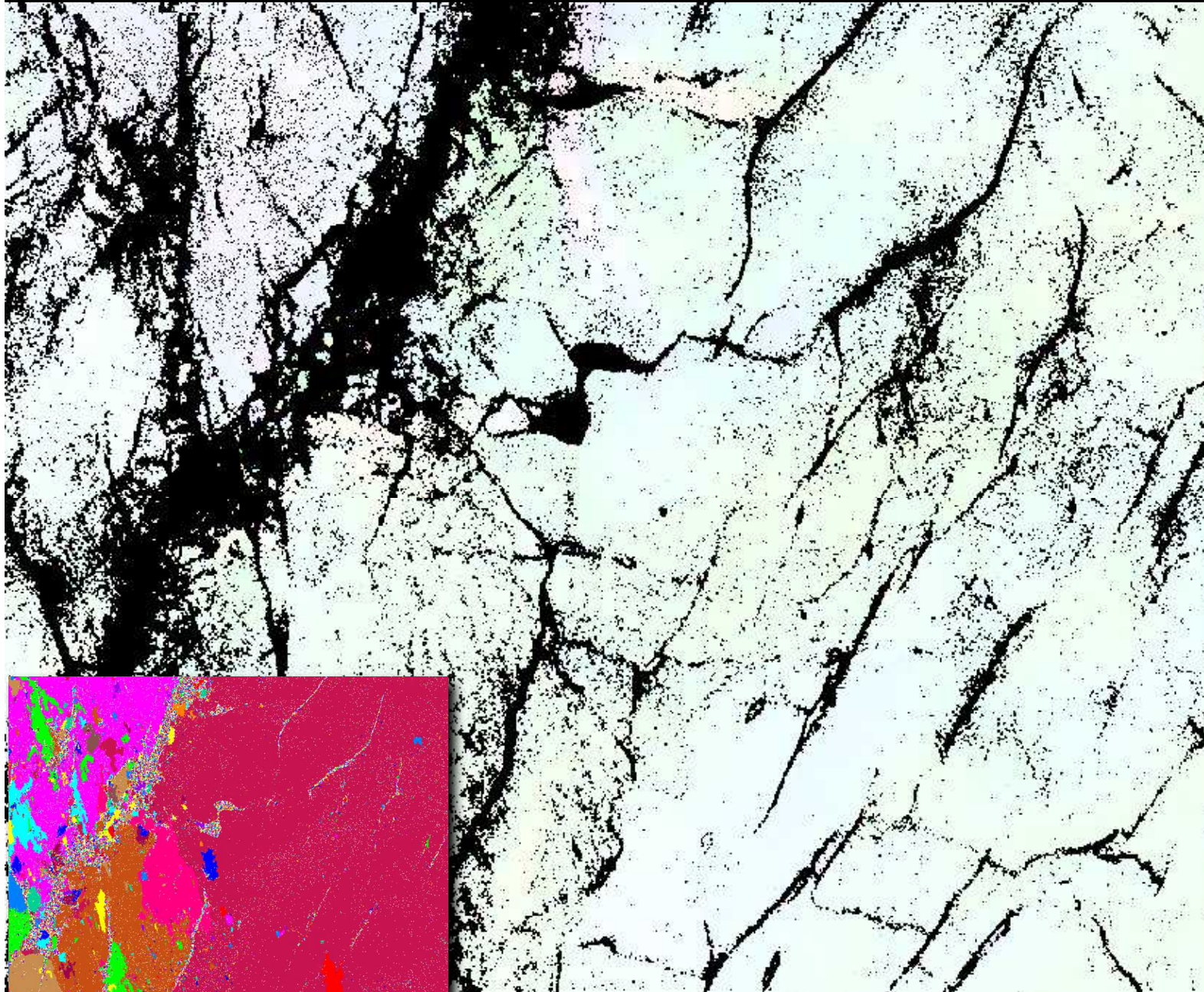


IPF of
transverse
direction



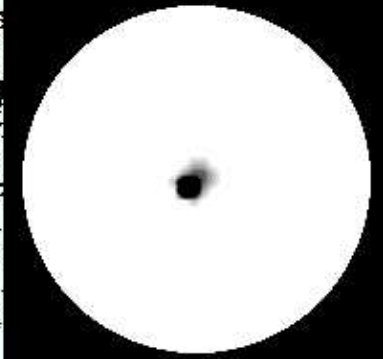
"grain map"



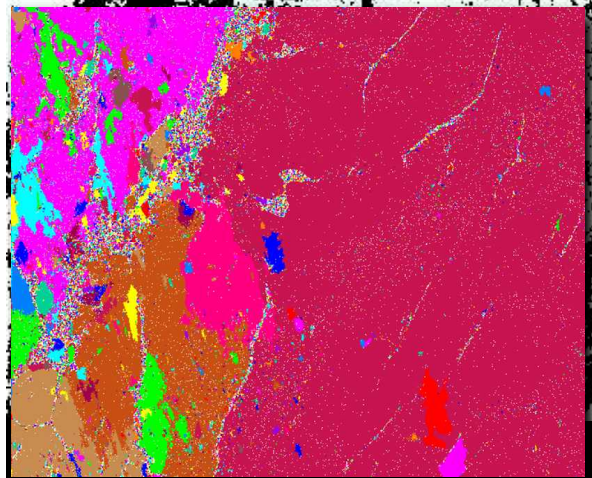


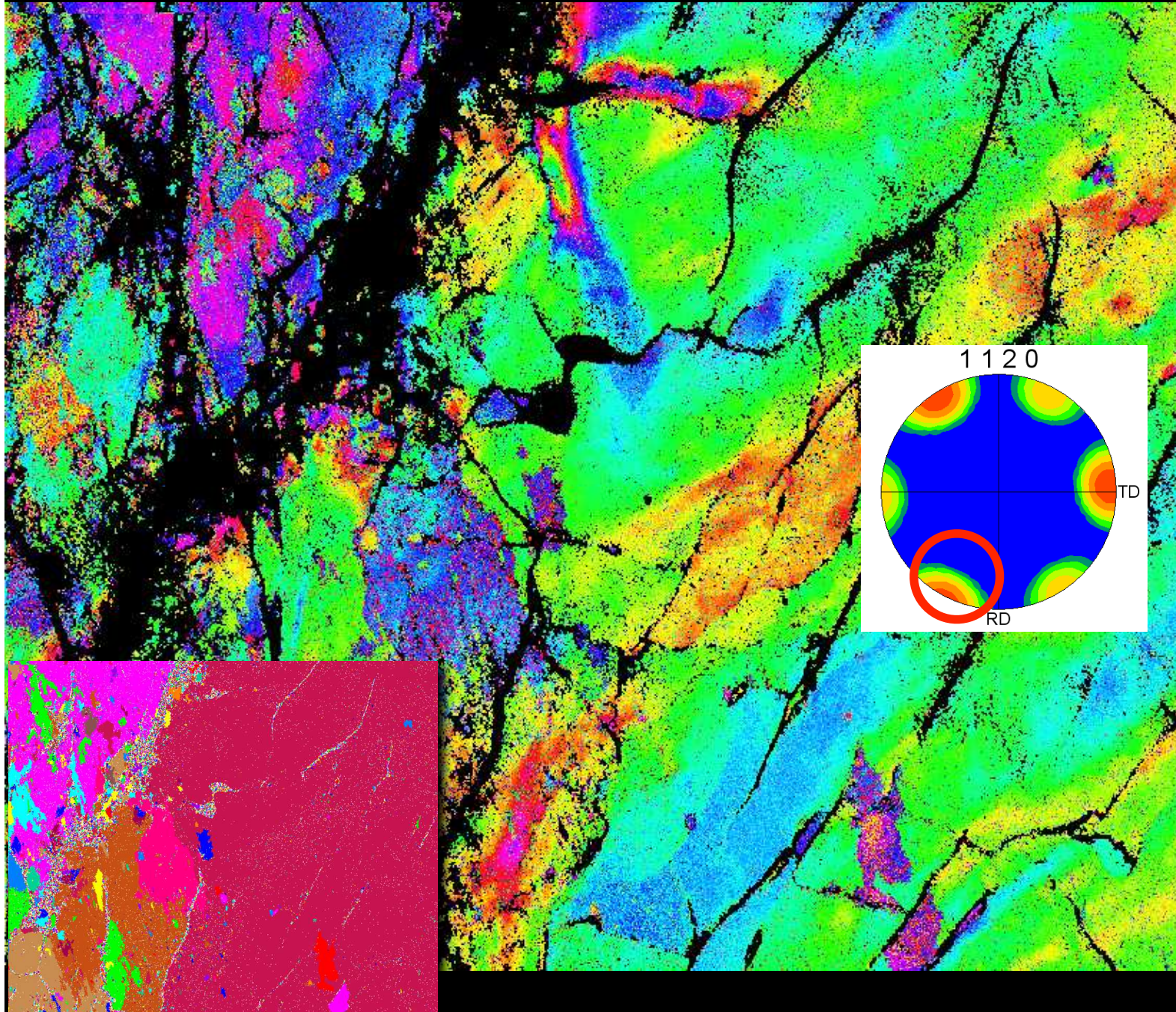
qtz144 06
c - axes

100 μm

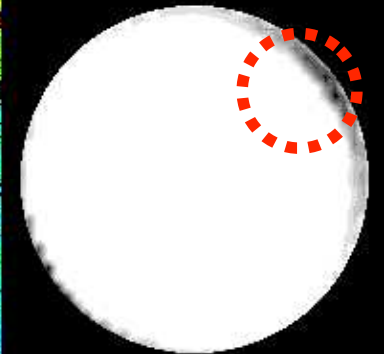
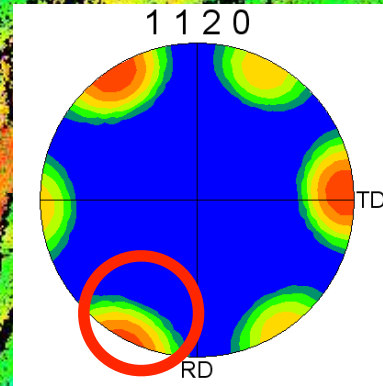


max = 180
10 - 80

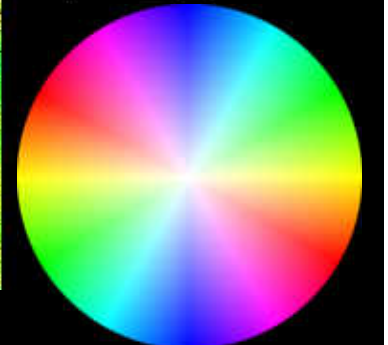




qtz144 06
a1

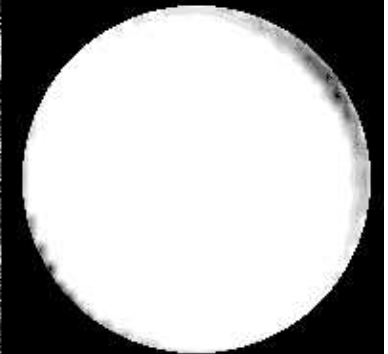


max=30.6
4 - 32

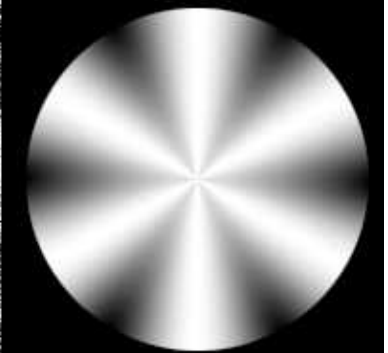




qtz | 44
EBSD
a1-axes
60° CLUT



max=30.6



summary

1. optical / orientation imaging (CIP / EBSD)
2. CIP - computer-integrated polarization microscopy
 - a. CPO as function of shear strain (COI, pdf)
 - b. orientation tracking (misorientations)
 - c. piezometry (orientation gradients: gb density)
3. CIP and EBSD
 - a. visualize EBSD using CIP
 - b. kinematic directions: $\langle a \rangle$ axes
 - c. deformation of single crystal of quartz

end

more info:

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