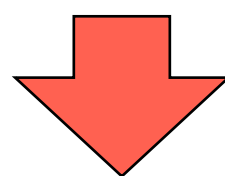
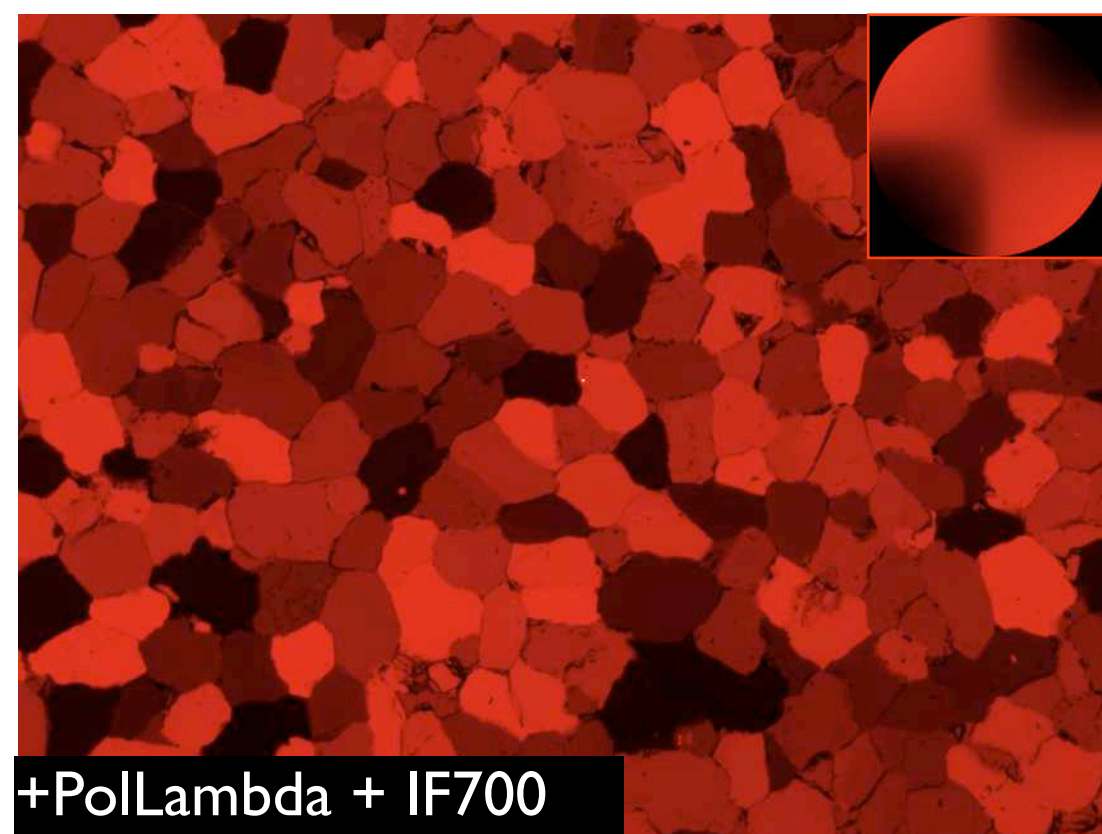
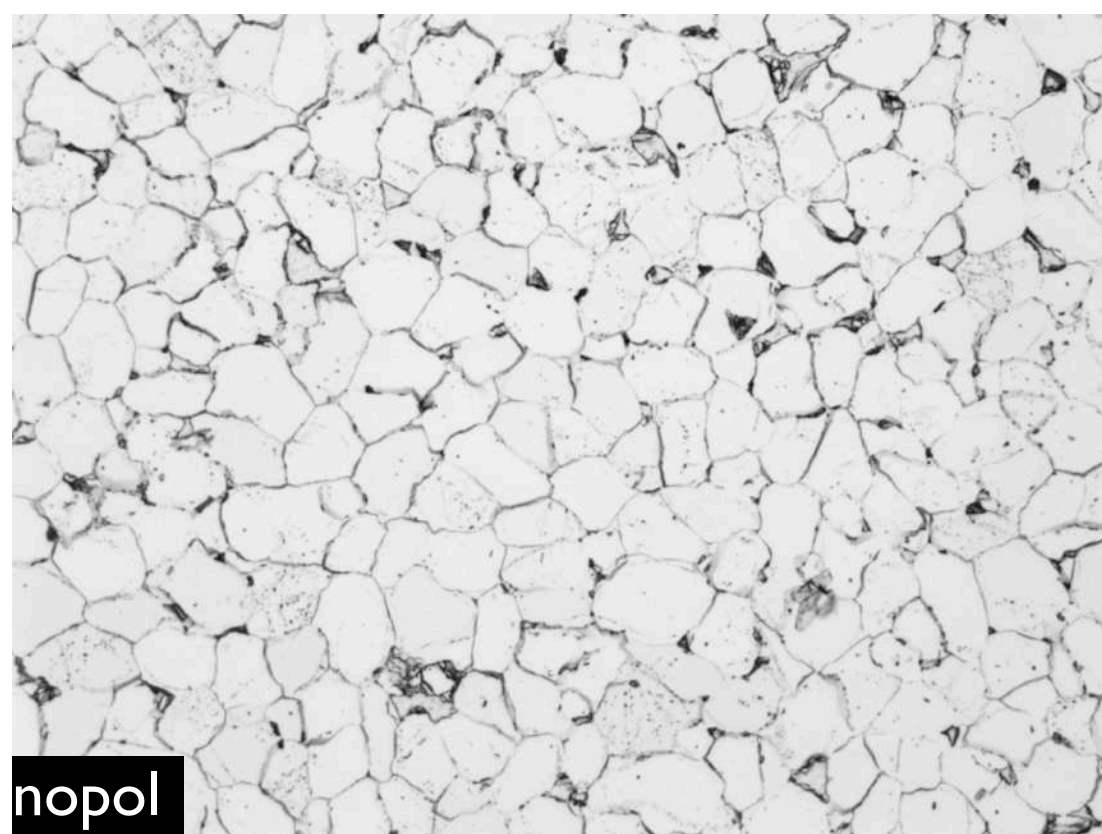
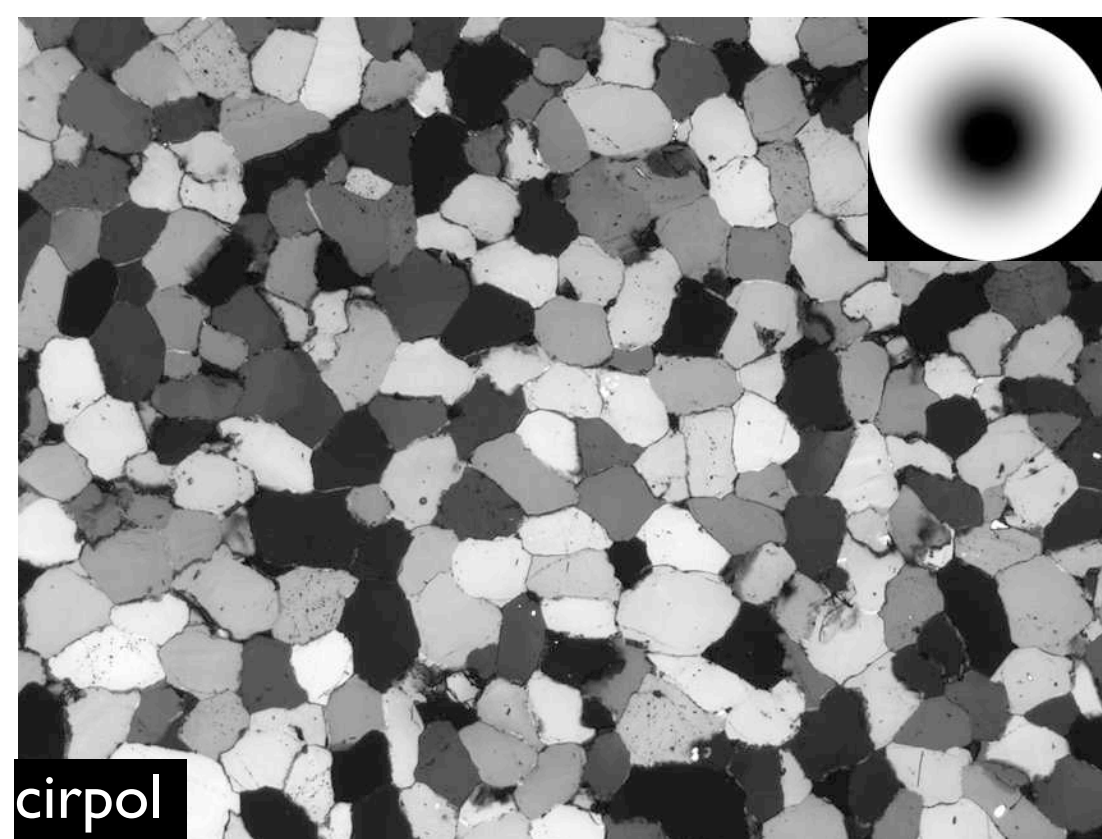
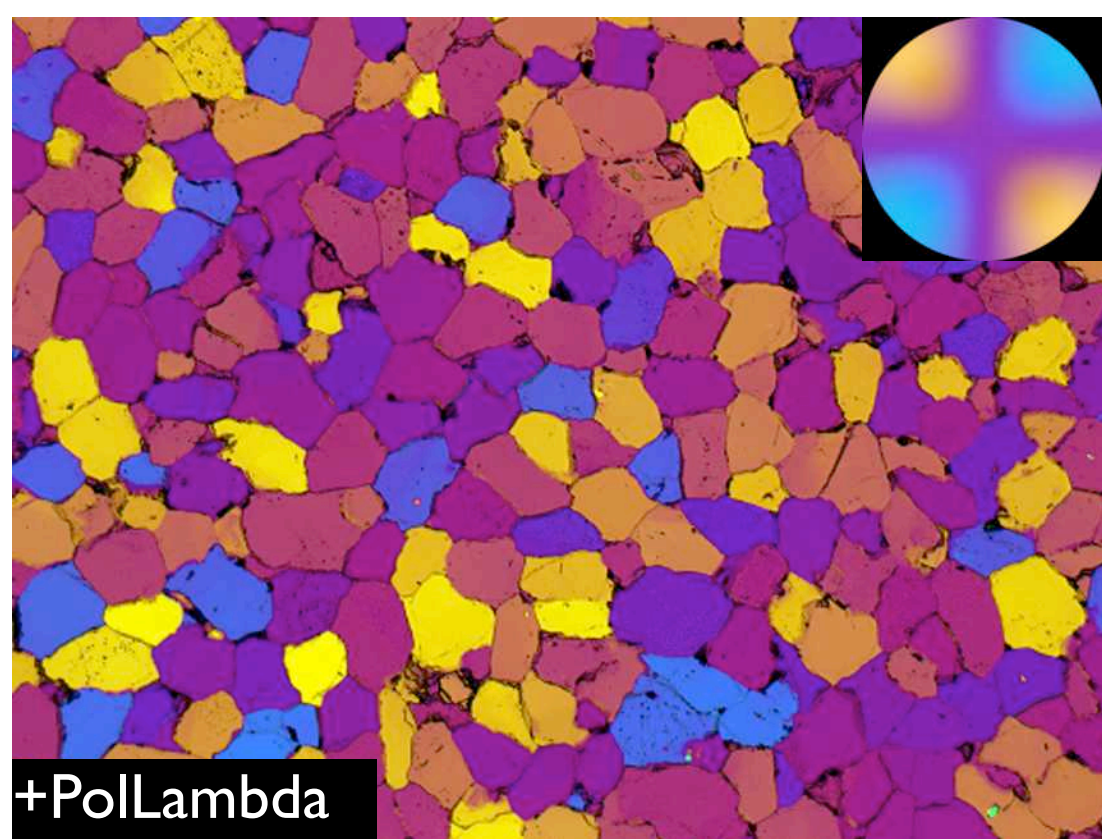
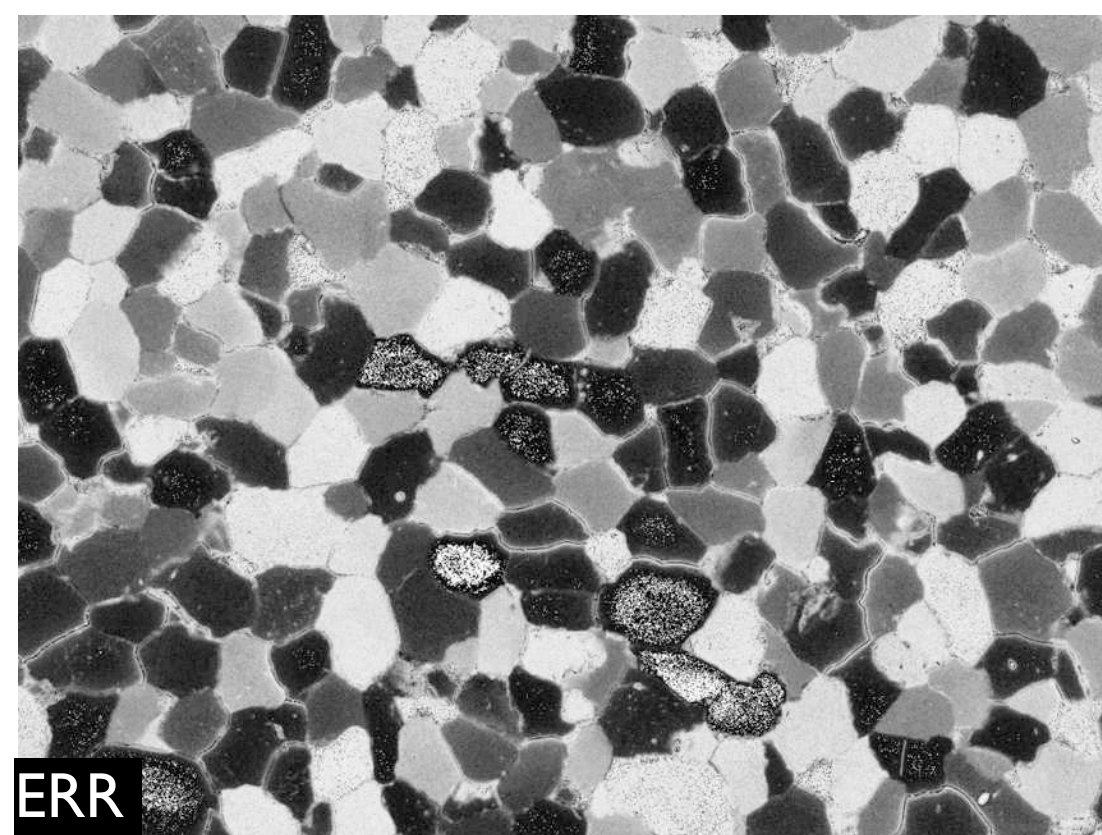
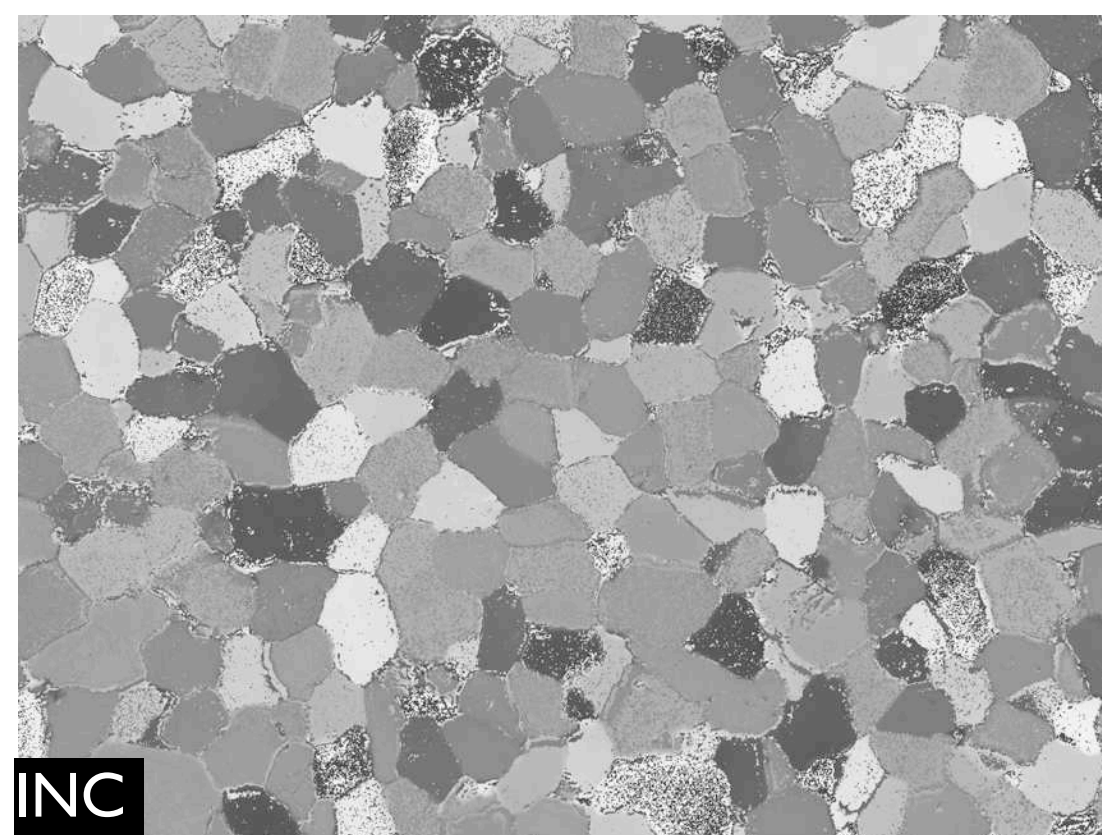


**a****b**



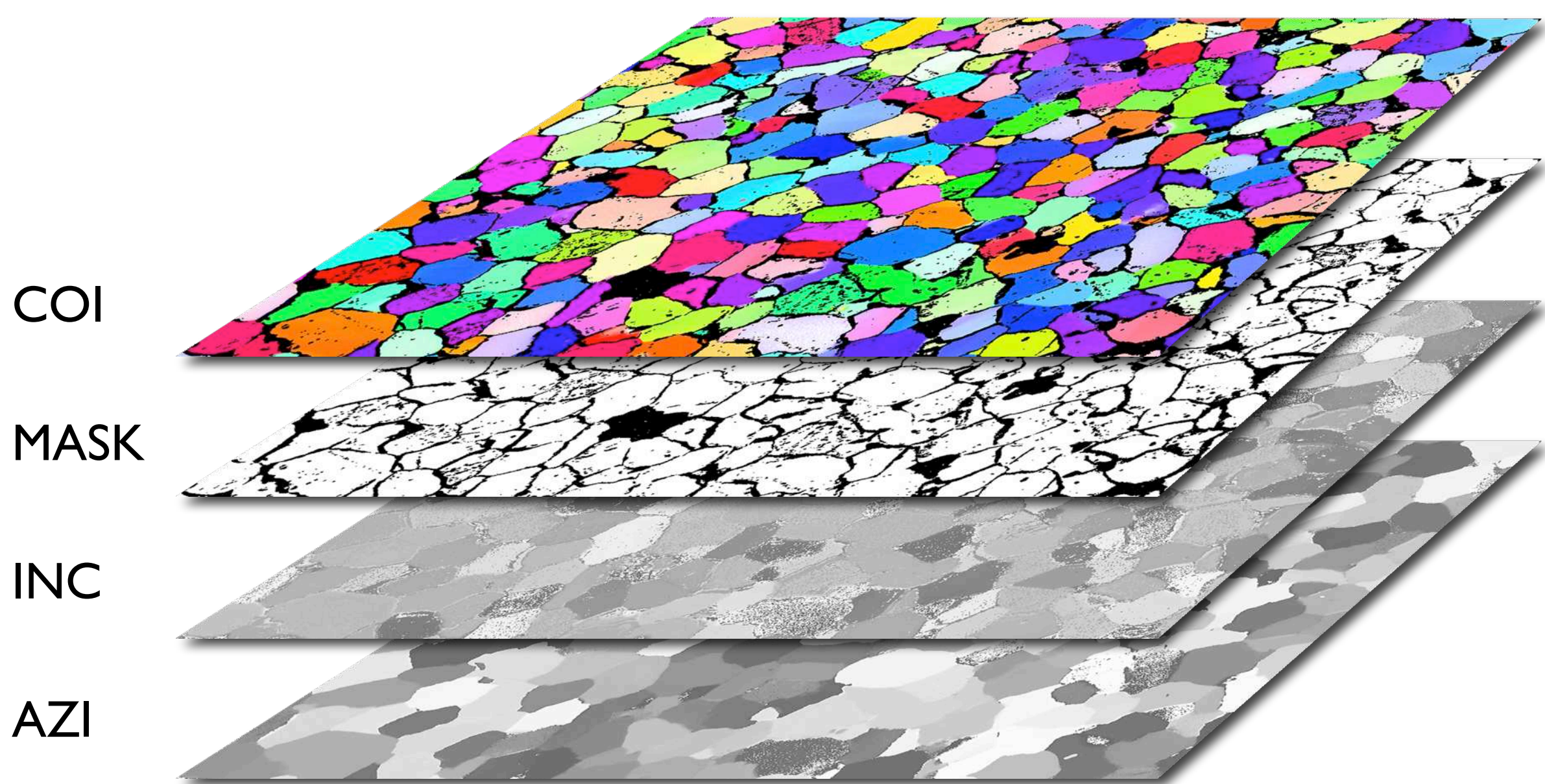
## **Figure 22.1**

CIP input and output.

Computer-integrated polarization microscopy (CIP) calculates the c-axis orientations of uni-axial minerals from polarized micrographs and presents the results as orientation images. The example shown here is a thin section of Black Hills quartzite.

(a) Input: micrograph taken under three different conditions of polarization: 1. crossed polarizers plus wave plate (+PolLambda), 2. circular polarization (cirpol), and 3. unpolarized (nopol); all images are acquired using a narrow band interference filter with a wavelength between 660 nm and 700 nm (here IF700); the effect of filtering the +PolLambda image is shown in the lower right;

(b) primary output: azimuth (AZI) and inclination (INC) image, c-axis orientation image (COI) with color-look-up table (CLUT); the quality image (ERR) shows high values (black) for poor quality, low values (bright) for good quality; misorientation and orientation gradient images can be derived from AZI and INC (see chapter 23).



COI

MASK

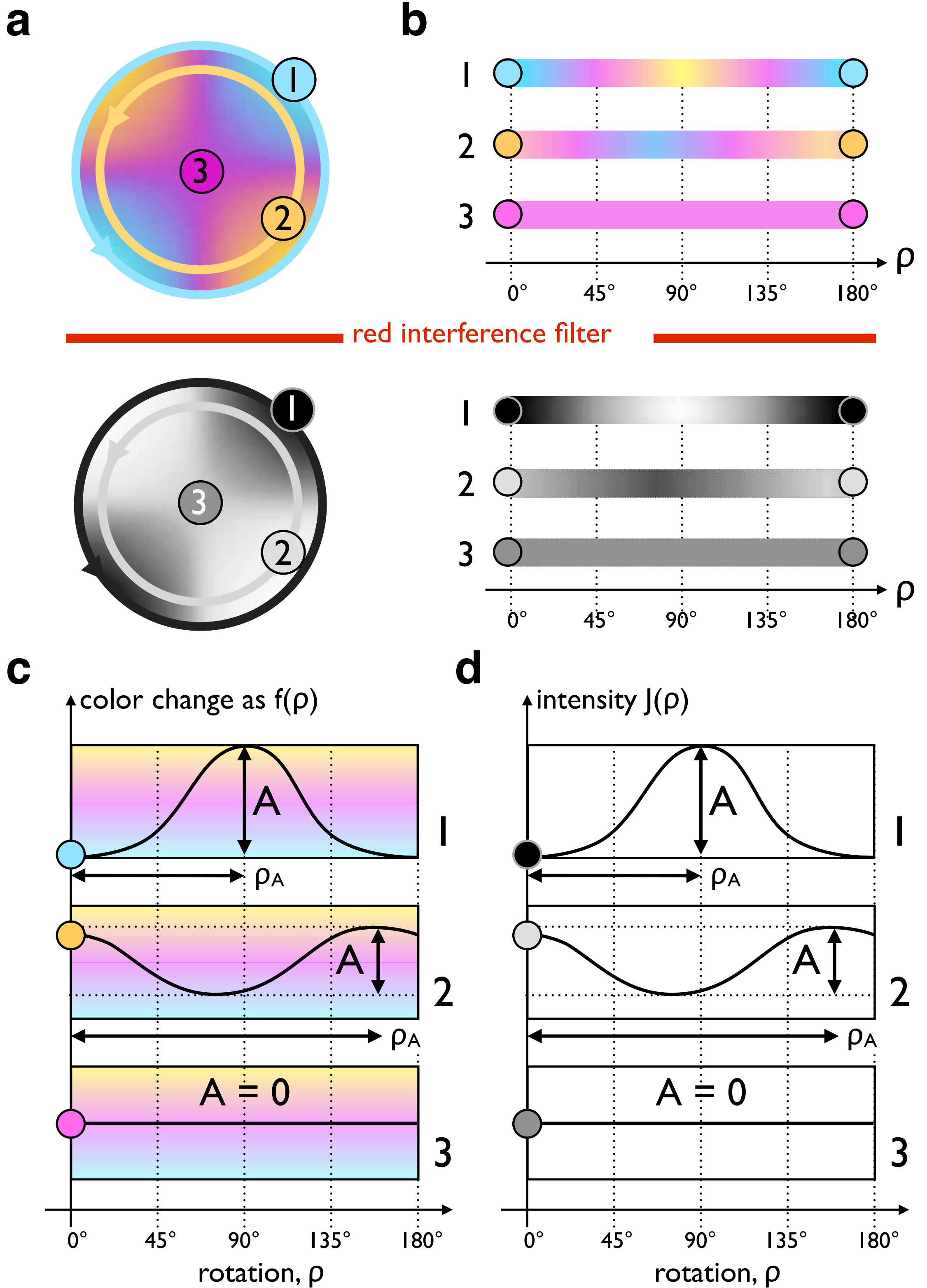
INC

AZI

**Figure 22.2**

The c-axis orientation image.

The c-axis orientation image (COI) is a multi-channel image composed of three channels: azimuth (AZI), inclination (INC), and mask (MASK).



**Figure 22.3**

Rotating c-axes.

Interference colors and monochrome intensities for three rotating c-axes; rotation,  $\rho$ , is about  $180^\circ$  (compare chapter 21, Figure 21.3 and 21.20); starting orientation of grains: (1)  $\varphi = 45^\circ$ ,  $\theta = 90^\circ$ ; (2)  $\varphi = 300^\circ$ ,  $\theta = 70^\circ$ ; (3)  $\theta = 0^\circ$ ;

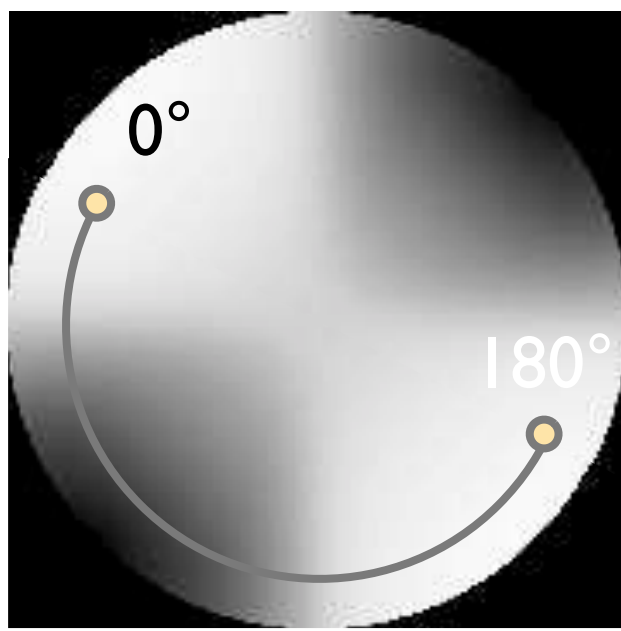
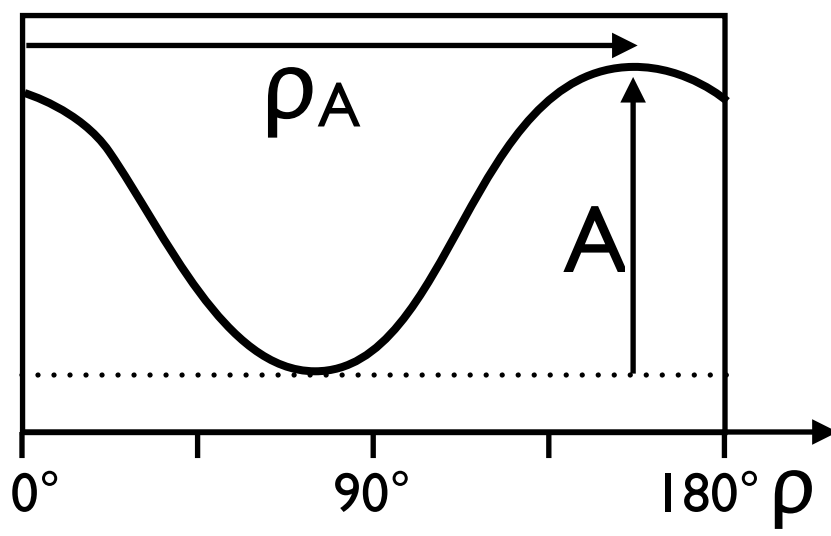
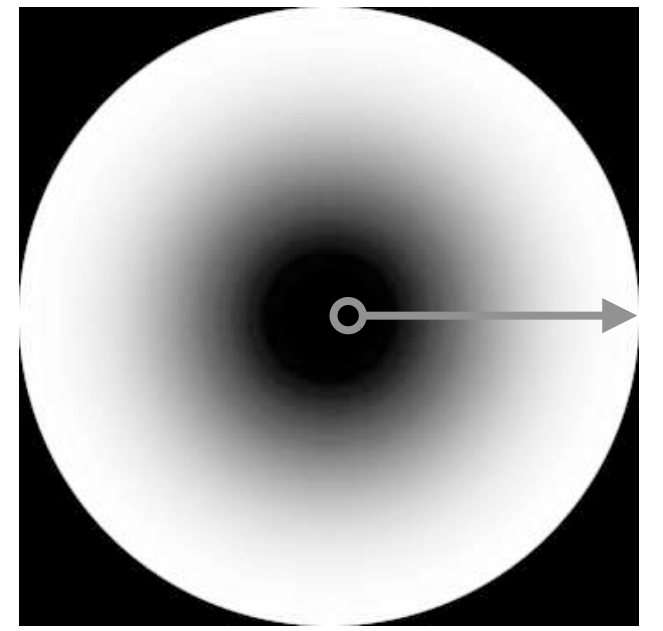
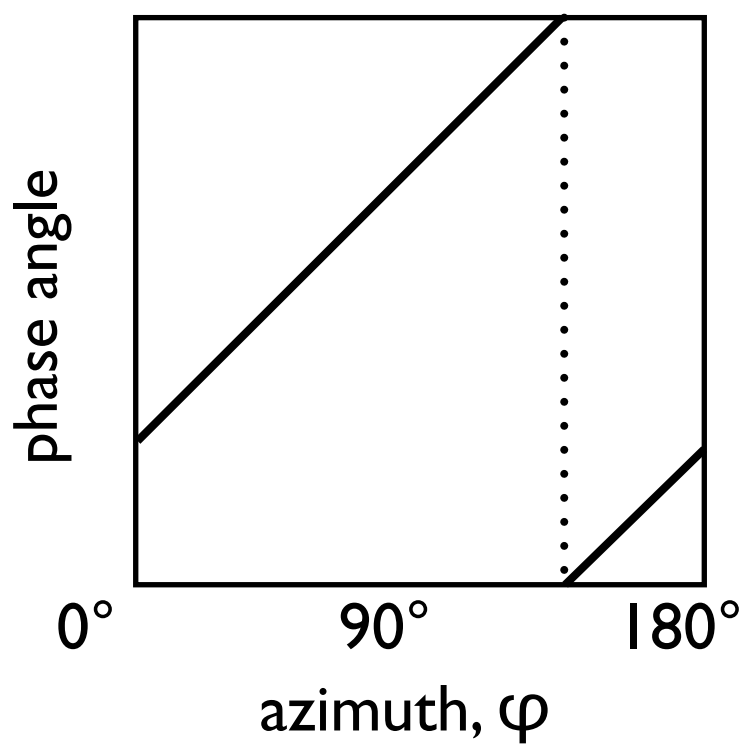
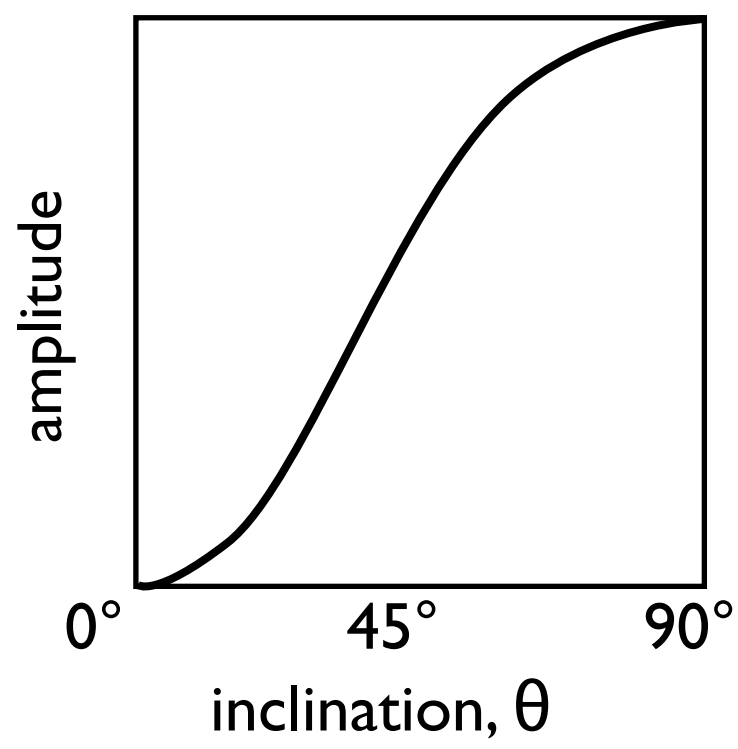
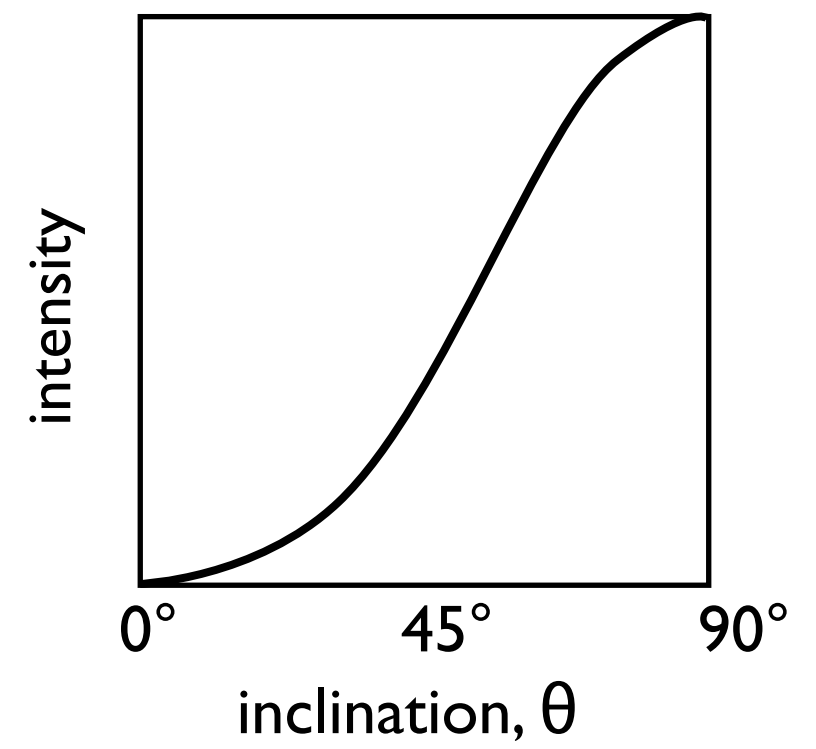
(a) conoscopic image with trajectories of rotating axes;

(b) changes of interference colors (top) and changes of intensities (bottom) as function of rotation,  $\rho$ ; a red interference filter is indicated schematically, converting the color changes (top) to intensity changes (bottom);

(c) the 'rotation signal' shown as color change;

(d) same as (c) as intensity change,  $J(\rho)$ .



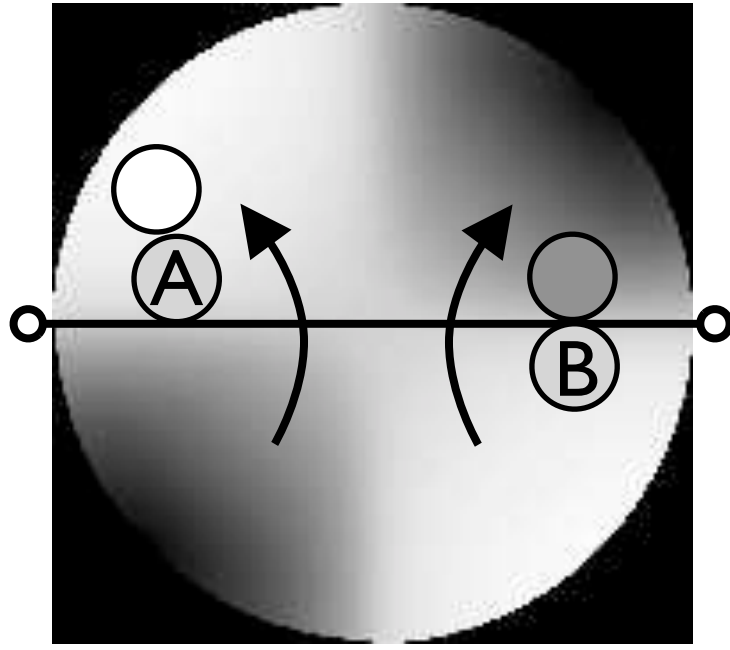
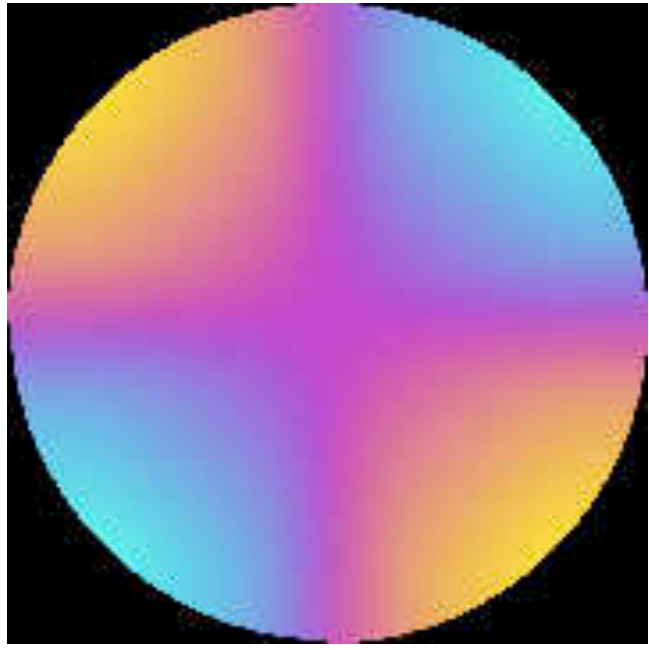
**a**intensity  $J(\rho)$ **b** $\rho_A = \rho_A(\varphi)$  $A = A(\theta)$  $J = J(\theta)$ **Figure 22.4**

Input signals for calculation of azimuth and inclination.

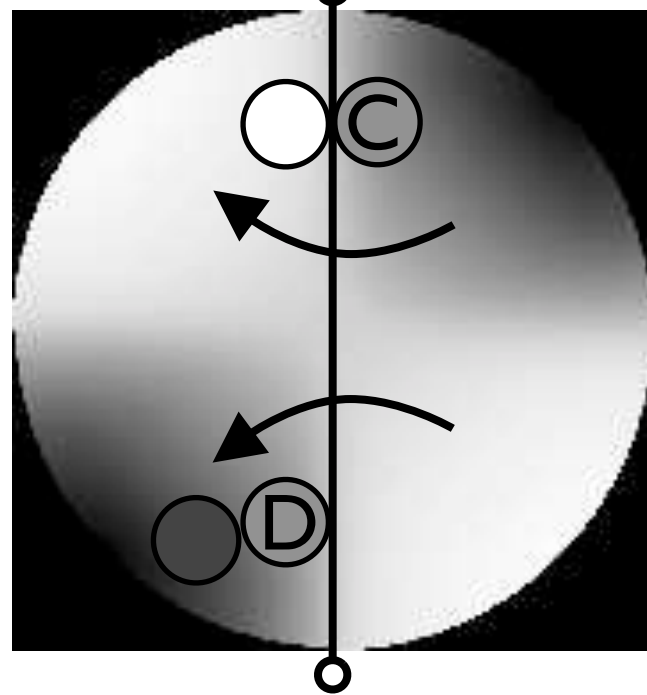
(a) Amplitude,  $A$ , and phase angle,  $\rho_A$ , from rotation; dependence of phase angle on azimuth,  $\rho_A(\varphi)$ , and amplitude on inclination,  $A(\theta)$ , are shown in square plots;

(b) intensity,  $J$ , from circular polarization; dependence of intensity on inclination,  $J(\theta)$ , is shown in square plot.



**a**

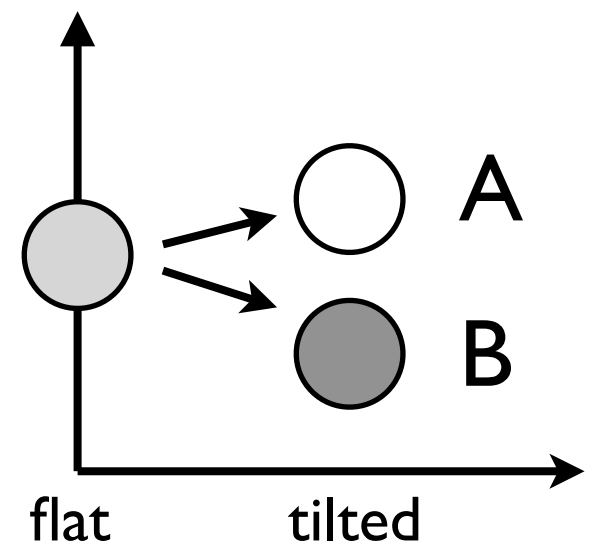
SUP



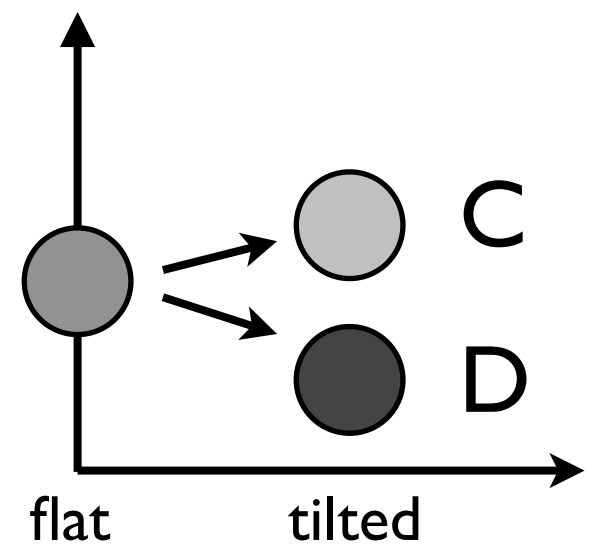
EUP

**b**

brightness



brightness

**Figure 22.5**

Deriving the full inclination.

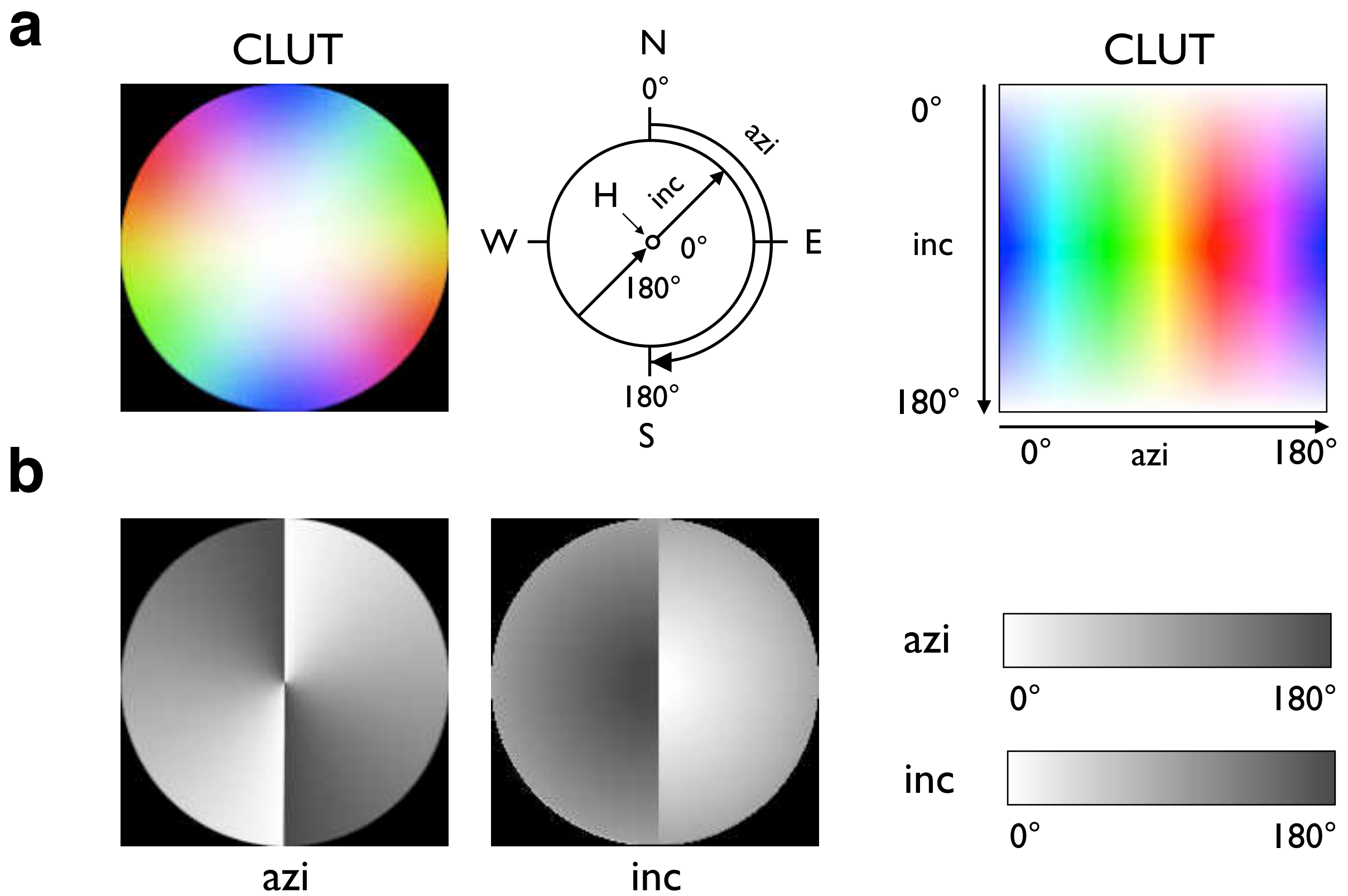
Two tilts are necessary to discriminate starting orientation A from B and C from D (compare Figure 21.4). Color and intensity (i.e., azimuth) of A and B and of C and D are identical, i.e., they are  $180^\circ$  apart; tilting changes the intensity of A, B, C and D; EUP = East Up = tilt about N-S axis; SUP = South Up = tilt about E-W axis.

(a) Tilt operations shown in the conoscopic images (color and monochrome);

(b) position of A is in the 4th quadrant because intensity increases; B is in 2nd quadrant because intensity decreases; analogously, C is in 1st quadrant while D is in 3rd.

Note, brightness encoding shows high intensities bright.





**Figure 22.6**

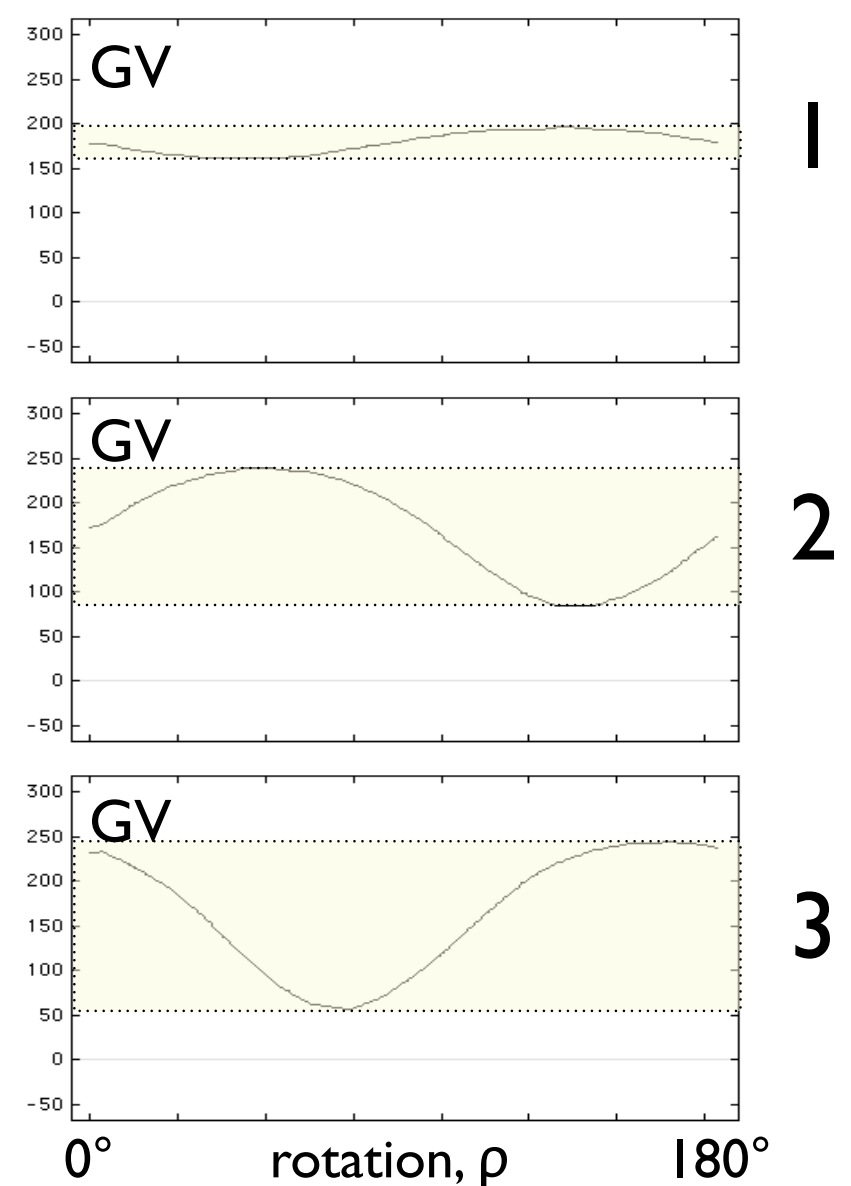
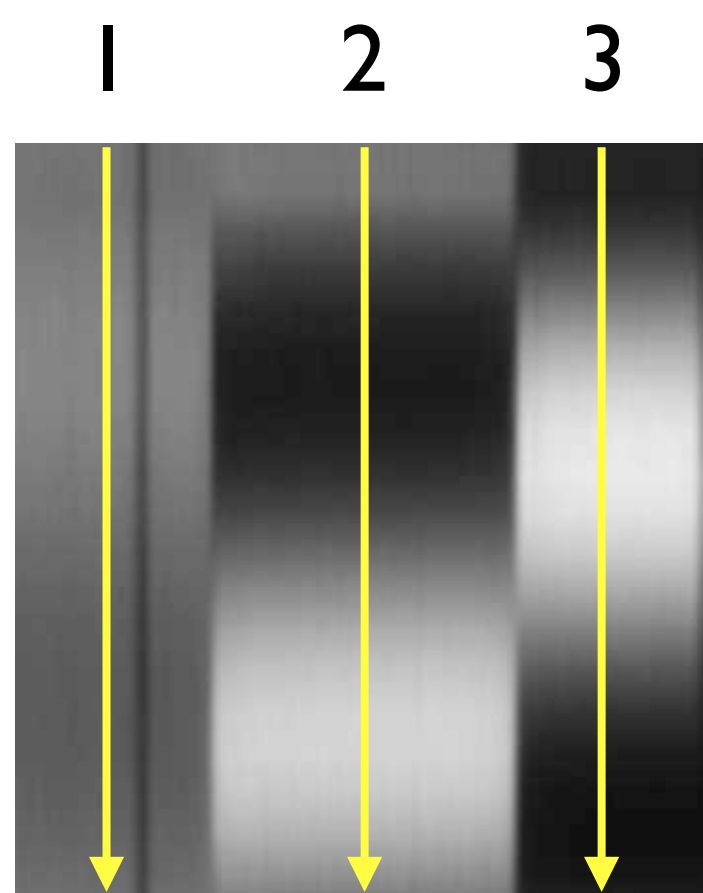
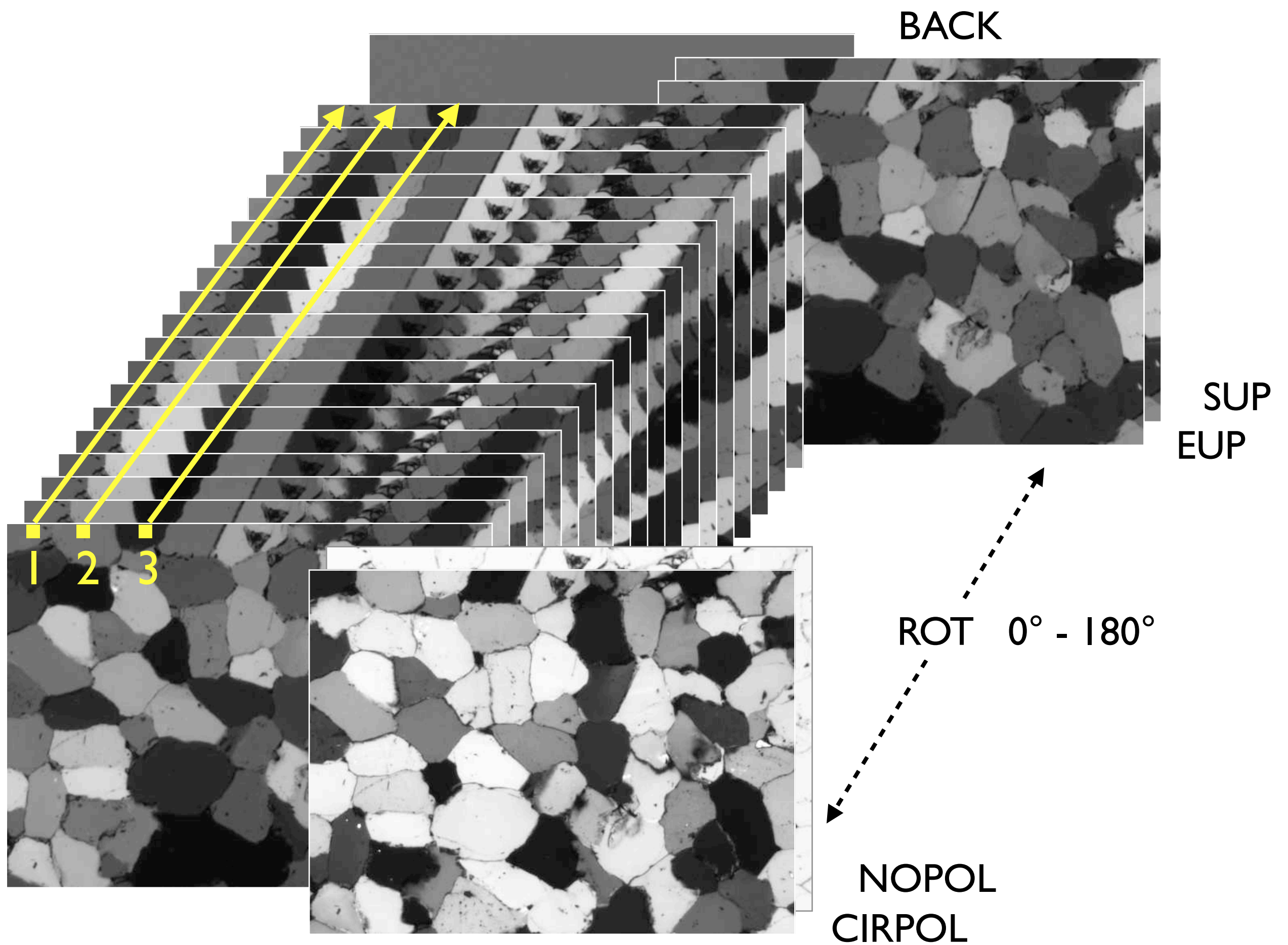
The coordinate system of c-axis orientation.

The range of values for azimuth,  $\varphi$ , and inclination,  $\theta$ , are  $(0^\circ \leq \varphi \leq 180^\circ)$  and  $(0^\circ \leq \theta \leq 180^\circ)$ .

(a) Color look-up tables (CLUT) are used to assign unique colors to every orientation  $(\varphi, \theta)$ ; they are two-dimensional and can be represented as a stereographic projection (left) or as a square matrix (right);

(b) look-up tables (LUT) for azimuth and inclination images (AZI and INC) are one-dimensional (right) but can also be represented as stereographic projections (left).





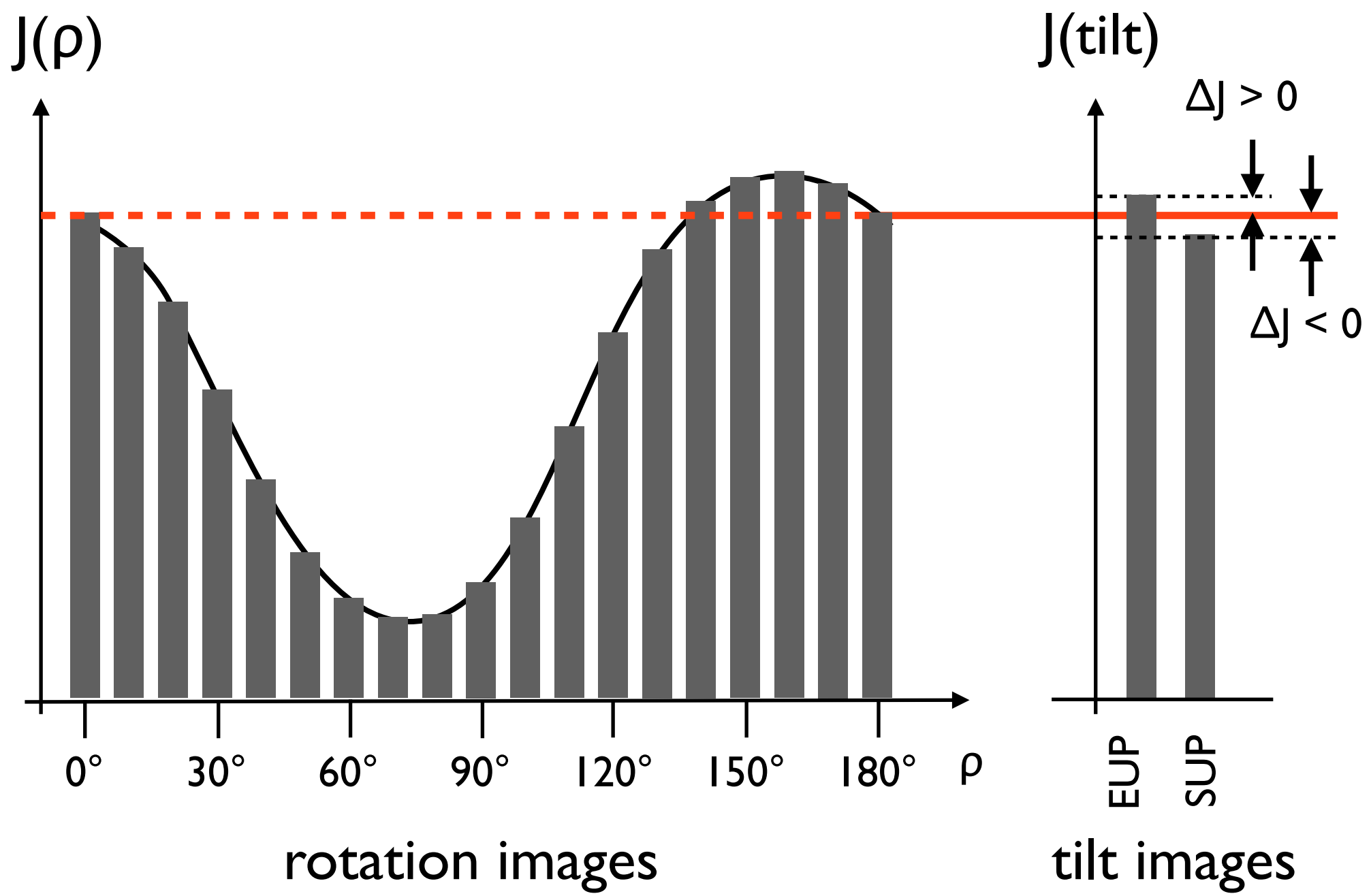
**Figure 22.7**

Input stack for CIP analysis.

The input stack consists of a minimum of 24 images.

(a) Input stack, from front to back: CIRPOL = 1 circular polarization image; NOPOL = one unpolarized or plane polarized image (used for making masks); ROT = 19 rotation images at  $10^\circ$  increments of rotation with respect to polarizer and wave plate; TILT = 2 tilt images where EUP = East edge Up, SUP = South edge Up (tilts must be perpendicular to each other); BACK = one background image, used to check/correct lighting conditions; 1, 2, 3 = traces for three pixels, see (b); (b) section through rotation images in stack, going through pixels 1, 2, 3; (c) gray value (GV) profiles on section (b) for pixels 1, 2, 3, showing low, medium and high amplitude (low, medium, high inclination).





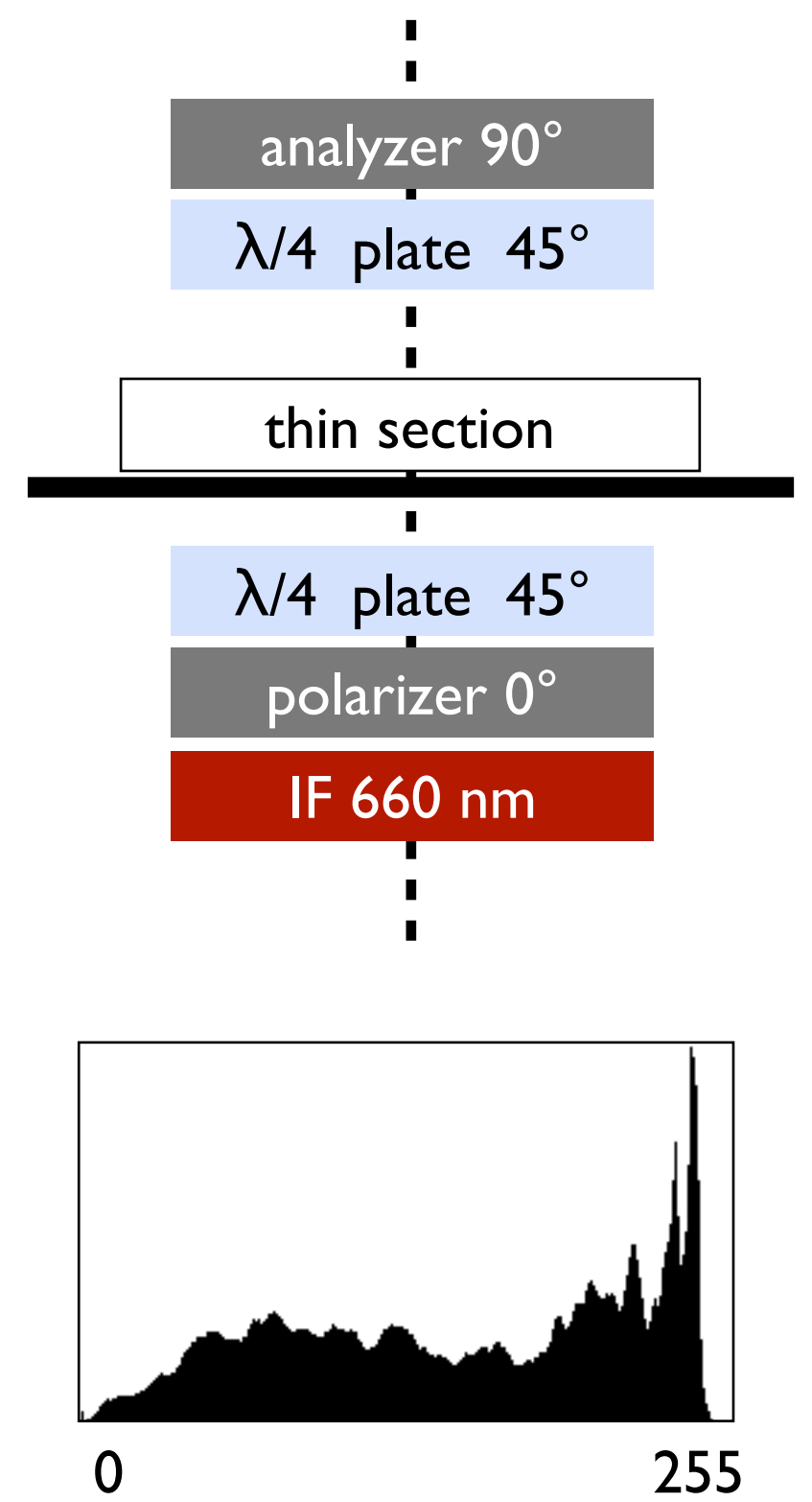
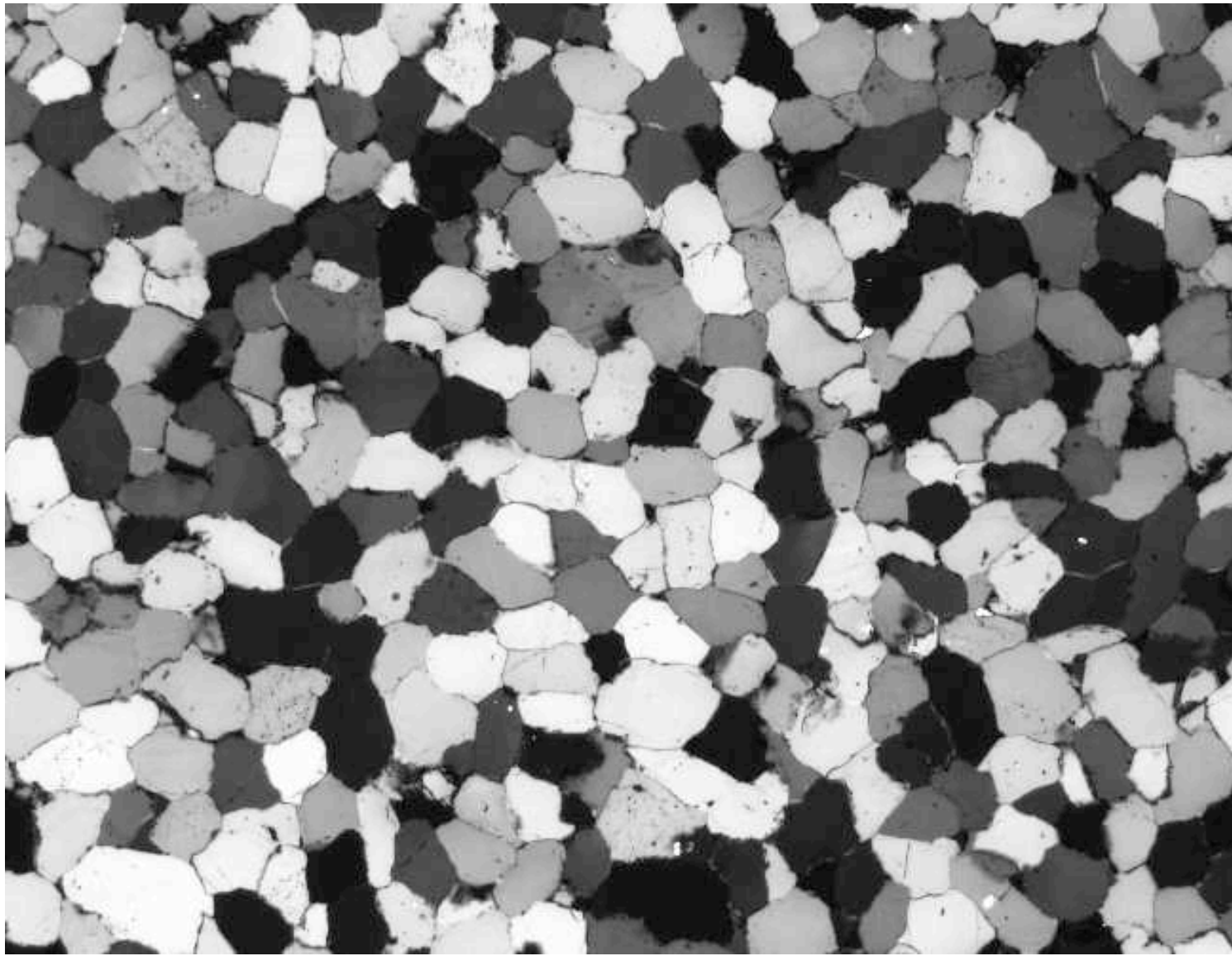
**Figure 22.8**

Intensity variations recorded in the input images.

19 intensity values,  $J(\rho)$ , corresponding to 19 increments of rotation, from  $0^\circ$ ,  $10^\circ$ , ..., to  $180^\circ$ , and two intensities corresponding to two tilts (East Up and South Up) are shown. The comparison of EUP and SUP with the last of the rotations ( $180^\circ$ ) decides if the starting orientation has to be 'flipped' to the other side of the orientation half space (where  $90^\circ < \theta \leq 180^\circ$ ).



# CIRPOL



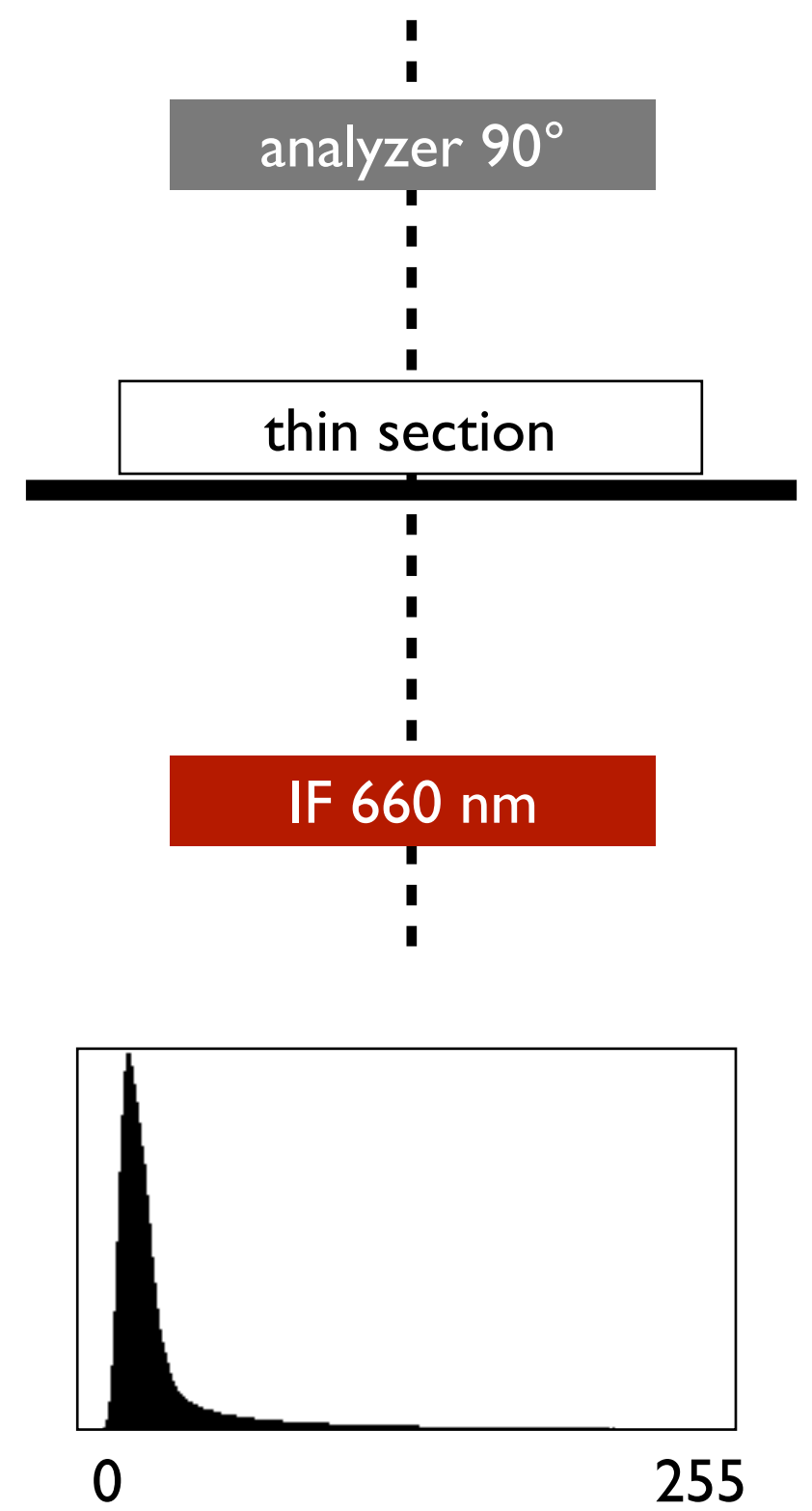
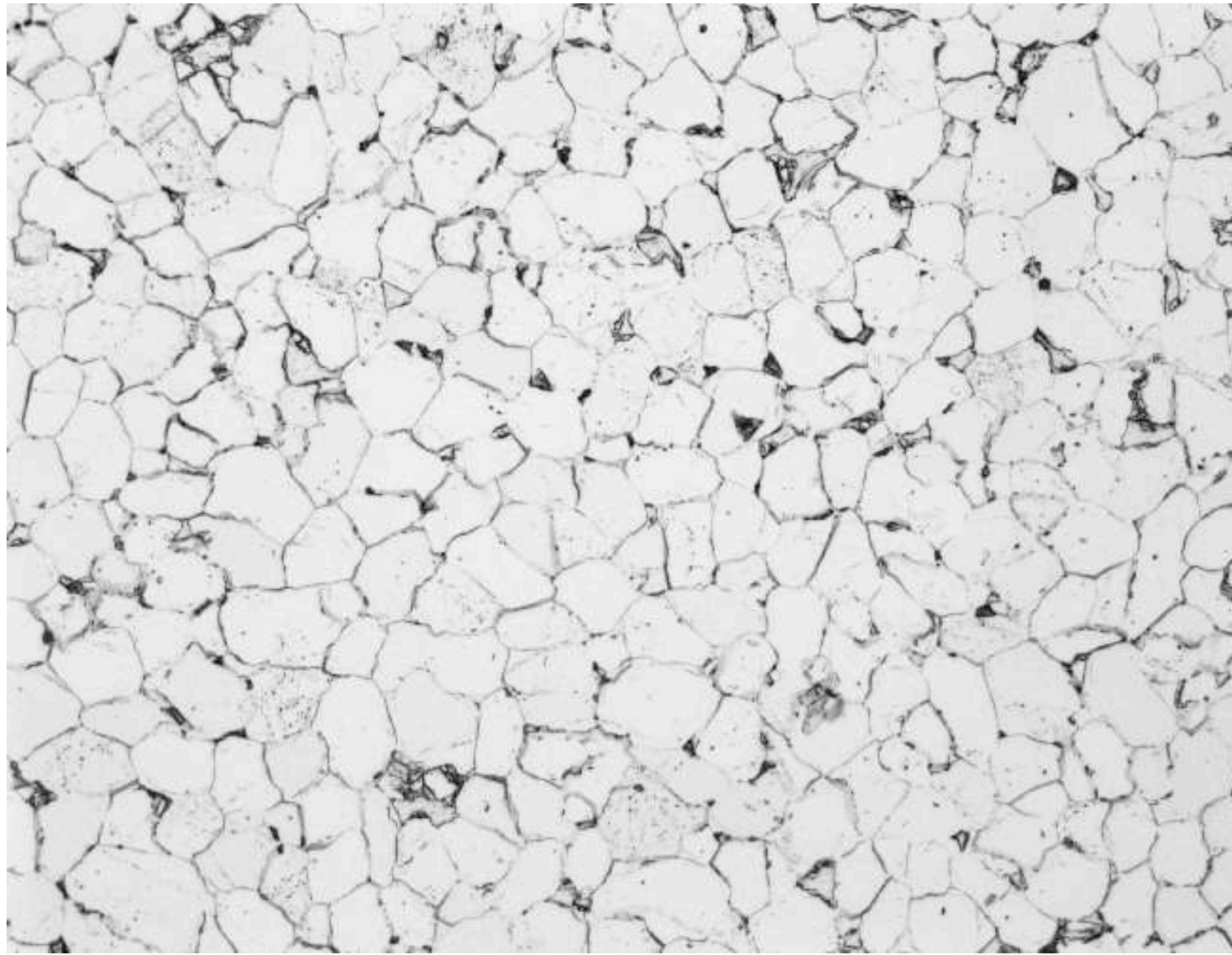
**Figure 22.9**

The circular polarization image.

Left: CIRPOL image; right: schematic drawing indicating where to insert two crossed polarizers ( $0^\circ$  and  $90^\circ$ ) and two quarter-wave plates ( $45^\circ$  orientation) in order to achieve circular polarization; red interference filter (IF 660 nm) is best inserted below polarizers (to protect polarizer from strong microscope light source); bottom right: histogram of image, 0 (white) to 255 (black).



# NOPOL

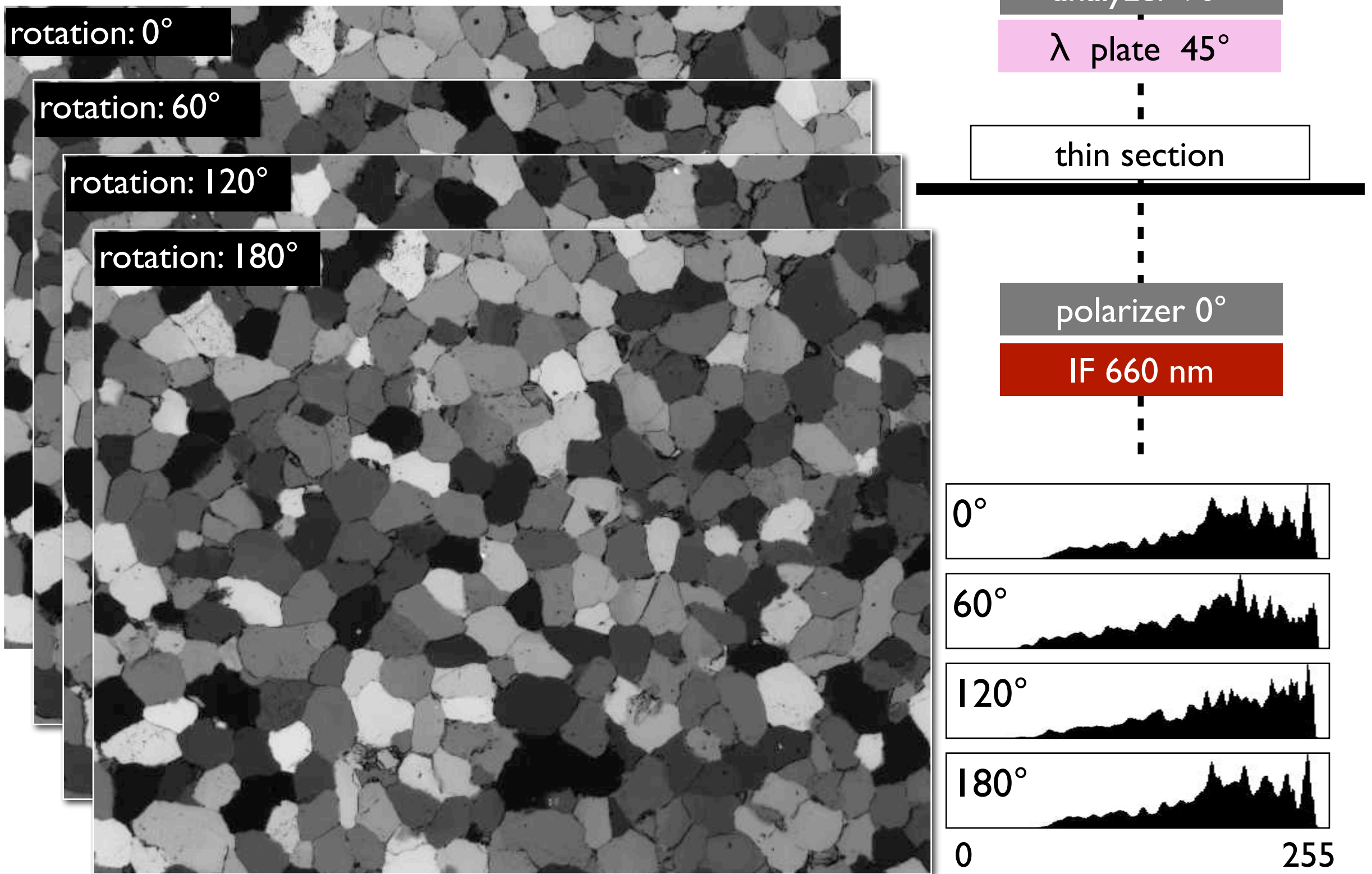


**Figure 22.10**

The unpolarized image.

Left: NOPOL image; right: schematic drawing indicating that polarizer should stay in to maintain magnification; red filter (IF 660 nm) also stays in to achieve maximum sharpness (avoiding remaining chromatic aberrations of microscope objectives); bottom right: histogram of image, 0 (white) to 255 (black).

# ROT



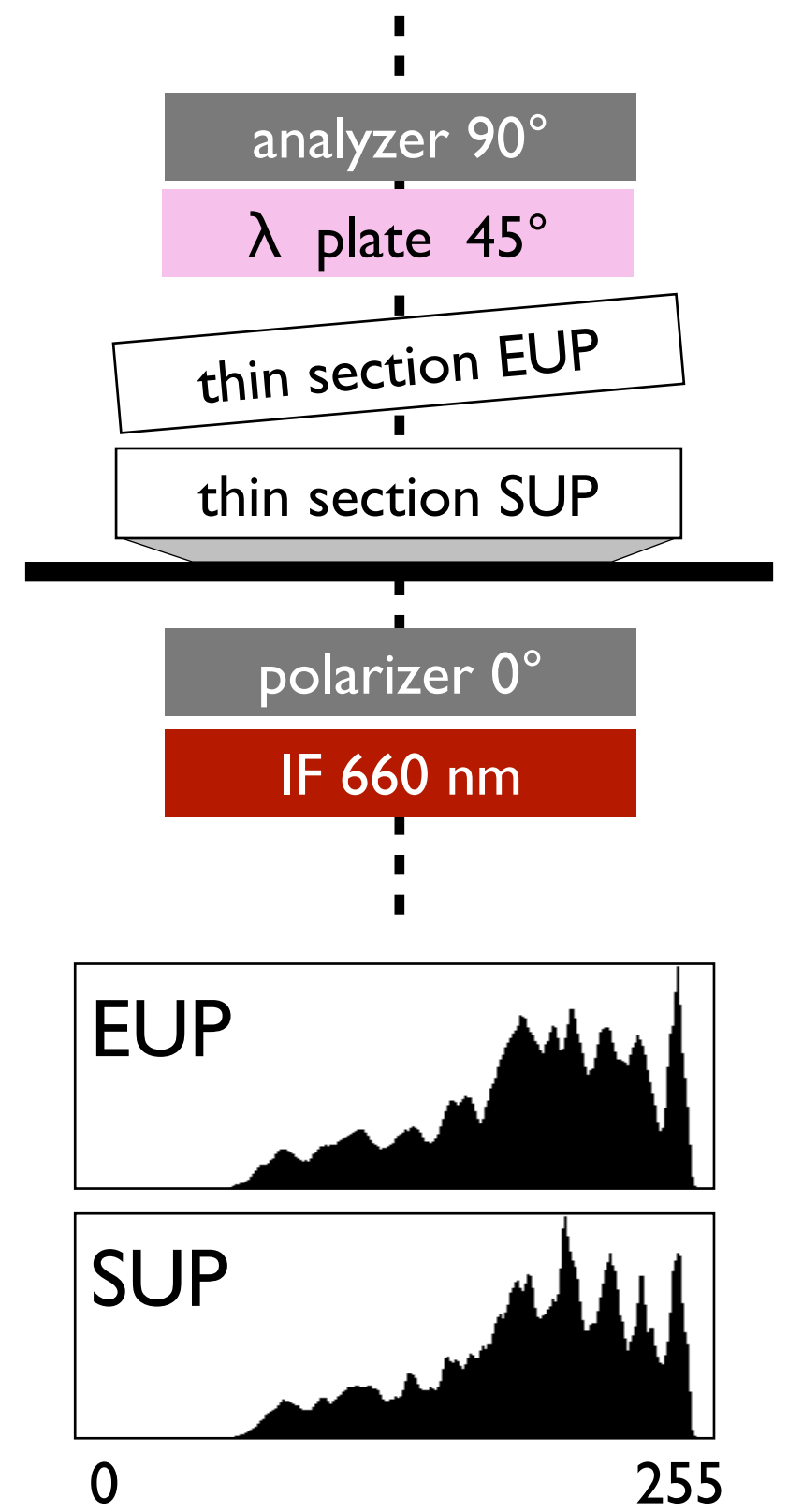
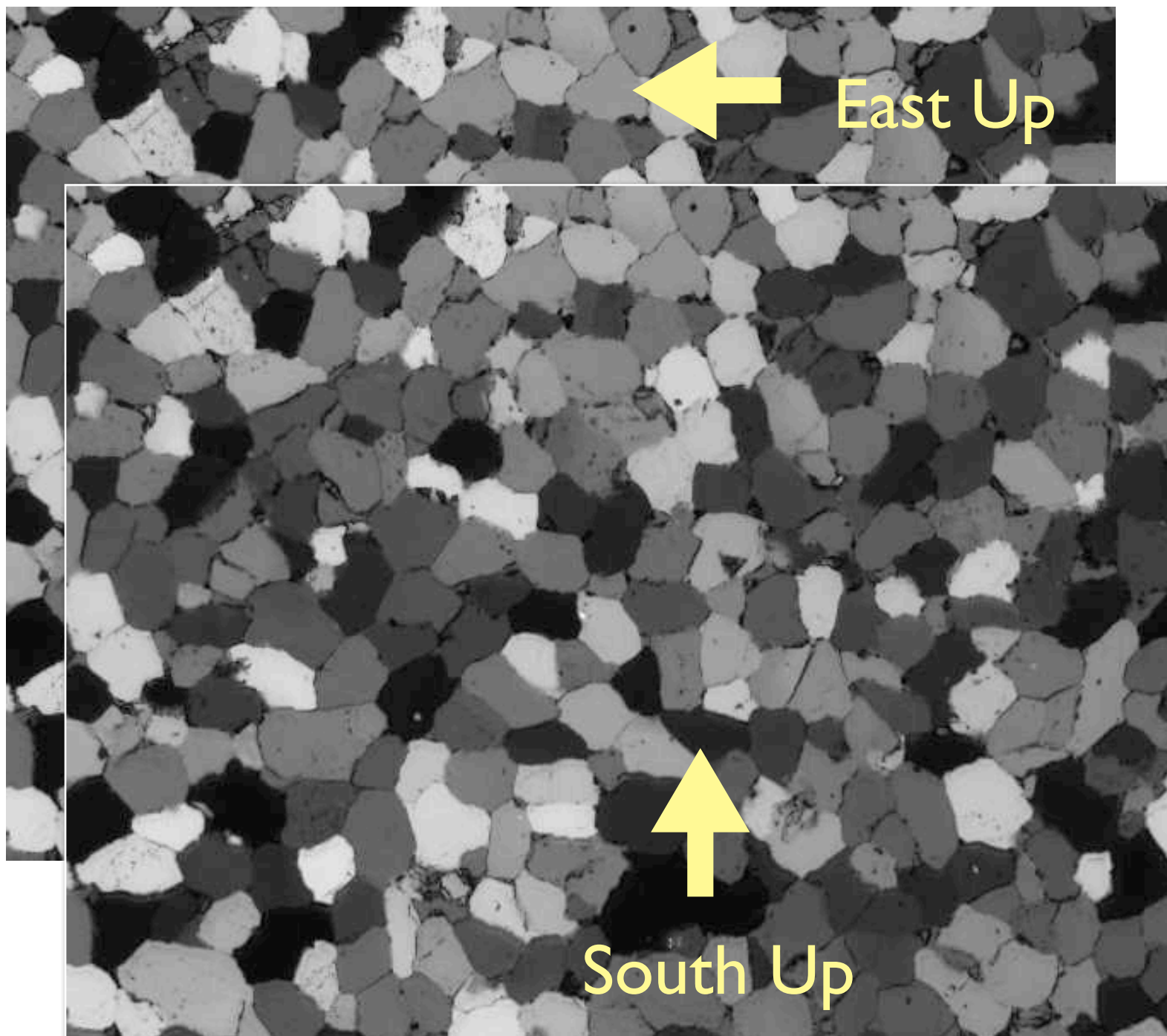
**Figure 22.11**

The rotation images.

Left: ROT images; right: schematic drawing indicating where to place two polarizers ( $0^\circ$  and  $90^\circ$ ), one (full) wave plate, and red filter (IF 660 nm); bottom right: histograms of rotation images, 0 (white) to 255 (black). Four rotations are shown:  $\rho = 0^\circ, 60^\circ, 120^\circ$ , and  $180^\circ$ ; ( $\rho = 180^\circ$ ) yields same image as ( $\rho = 0^\circ$ ).



# TILT



**Figure 22.12**

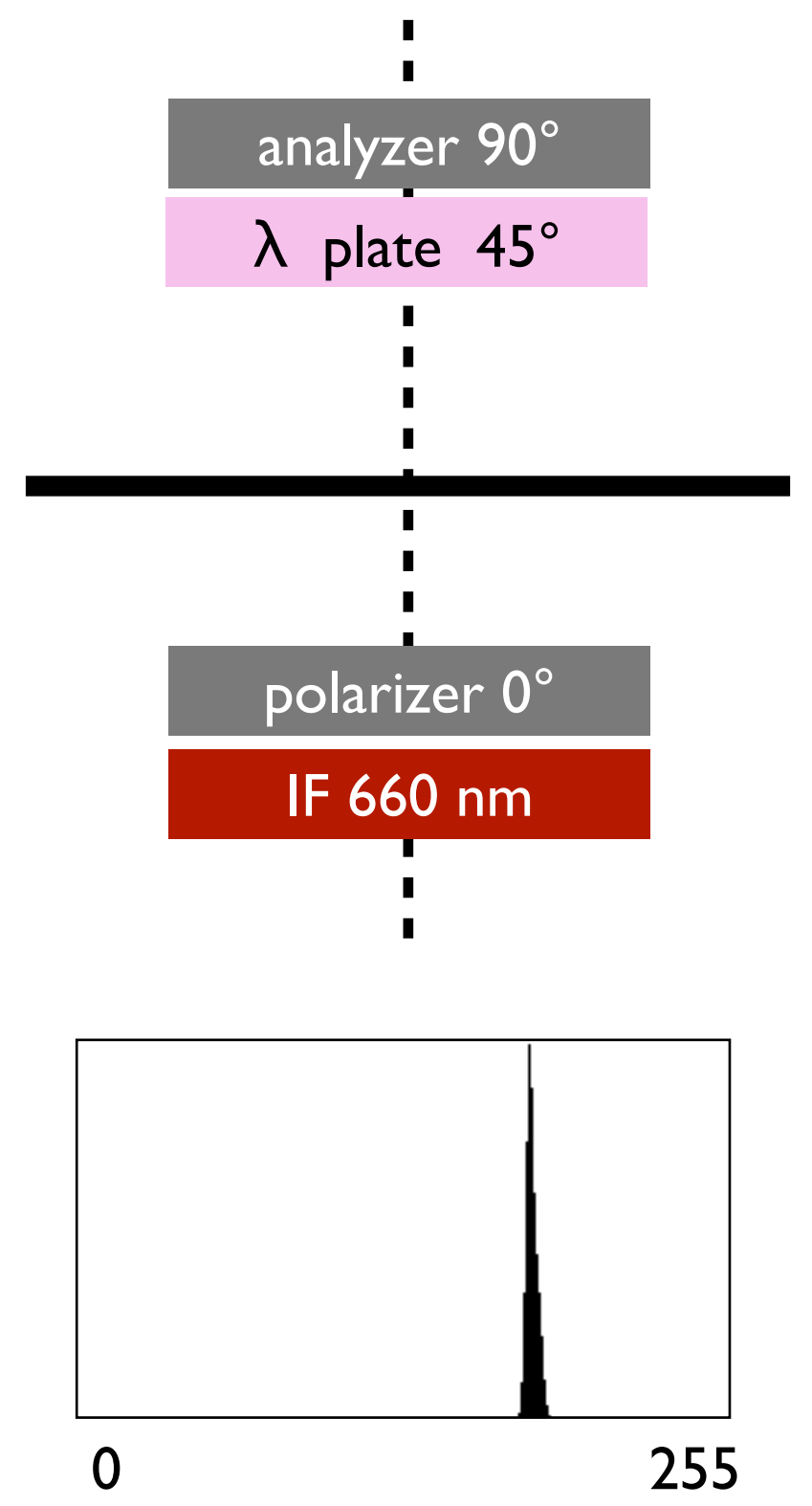
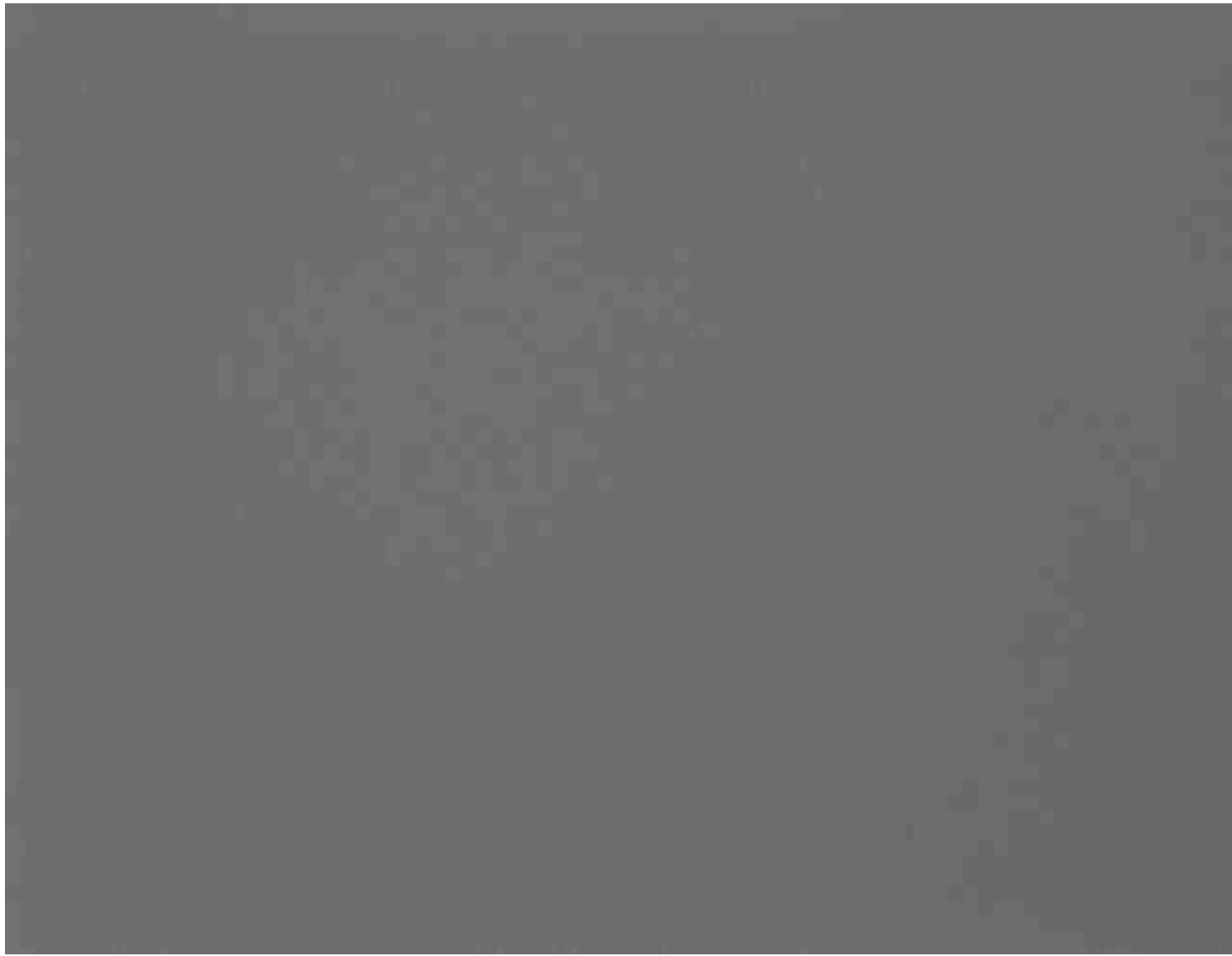
The tilt images.

Left: TILT images; right: schematic drawing indicating that polarizers, wave plate and red filter (IF 660 nm) remain fixed as for the rotation images; thin section is tilted (approx.  $5^\circ$ );

bottom right: histograms of tilt images, 0 (white) to 255 (black).

Tilts: East Up (EUP) = tilt about N-S axis; South Up (SUP) = tilt about E-W axis of microscope.

BACK

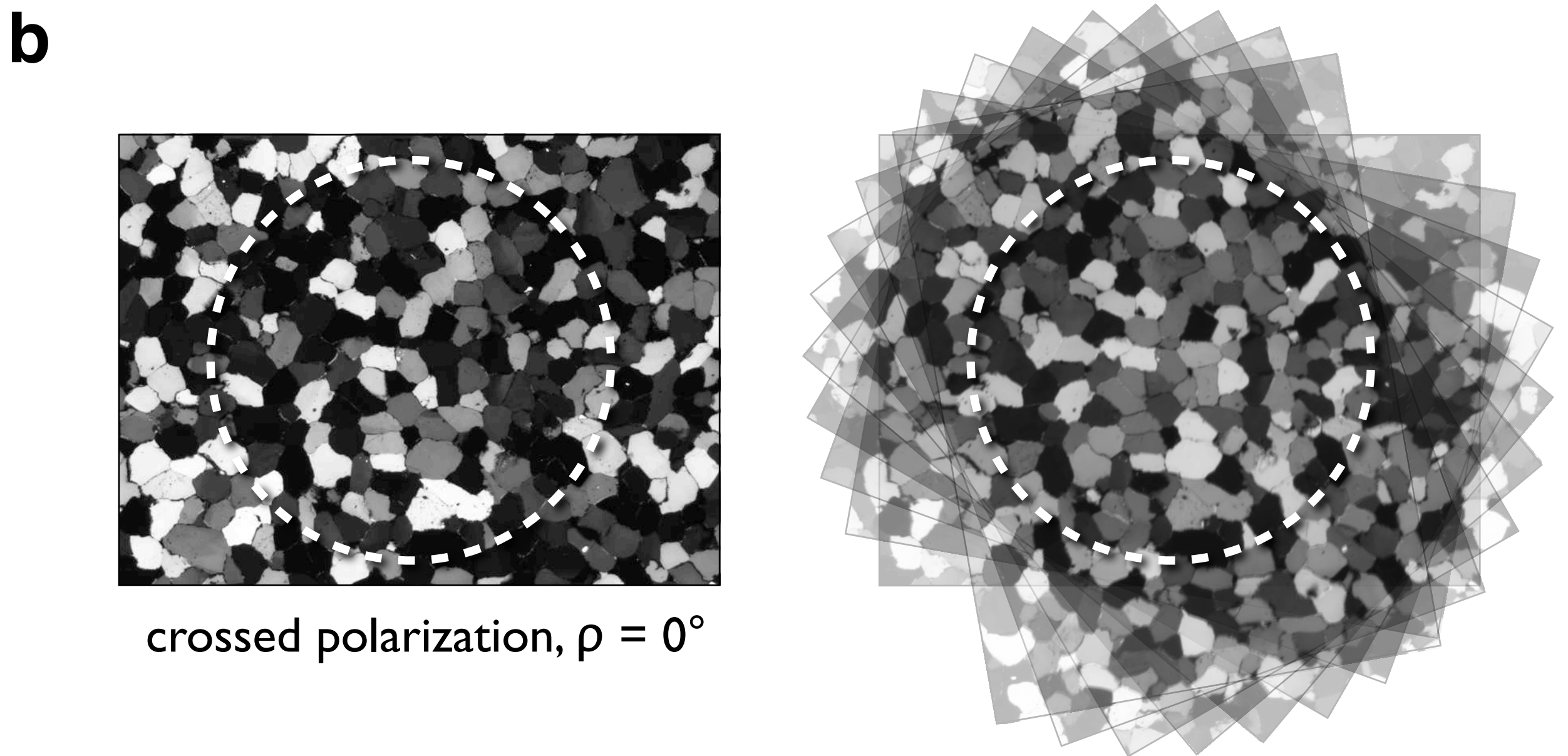
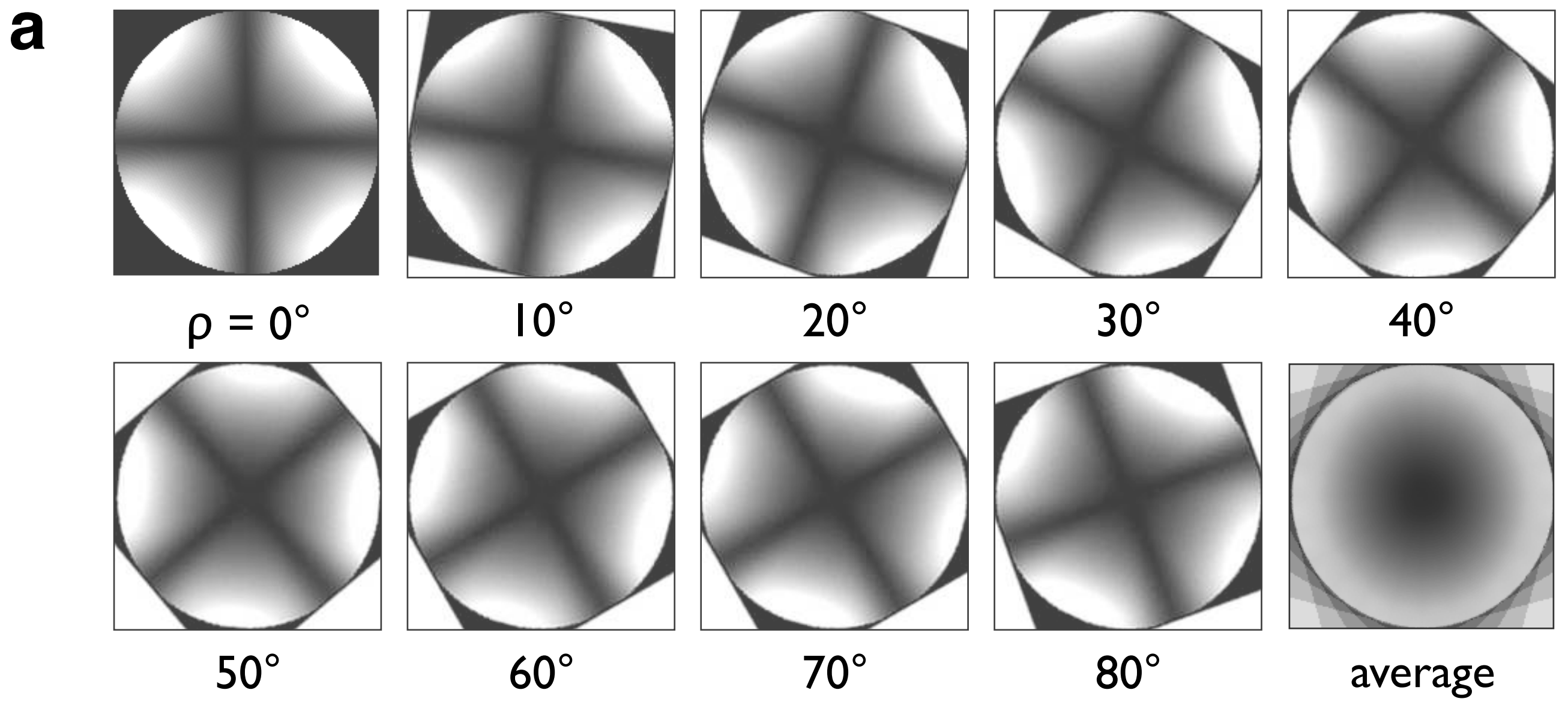


**Figure 22.13**

The background image.

Left: BACK image; right: schematic drawing indicating that polarizers, wave plate and red filter (IF 660 nm) stay in, thin section is removed; bottom right: histogram of image, 0 (white) to 255 (black).





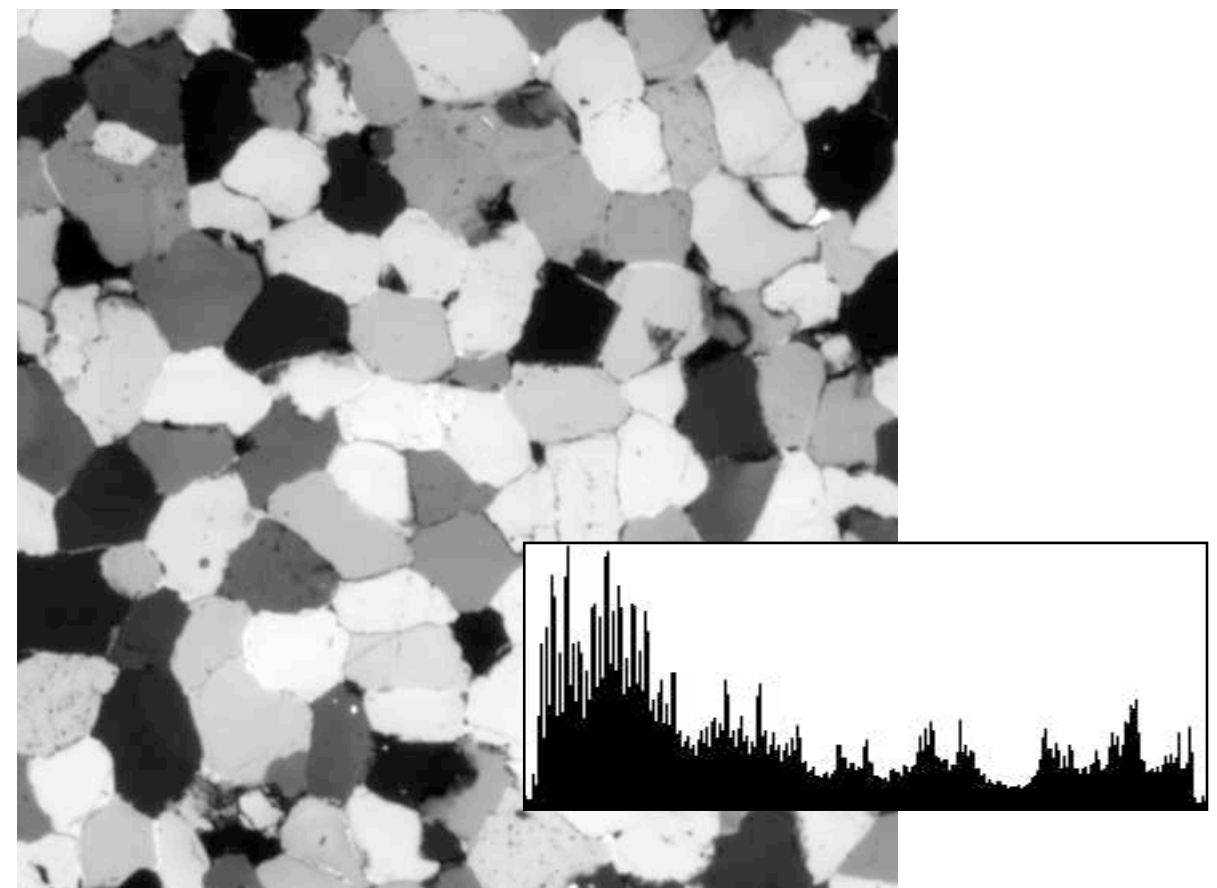
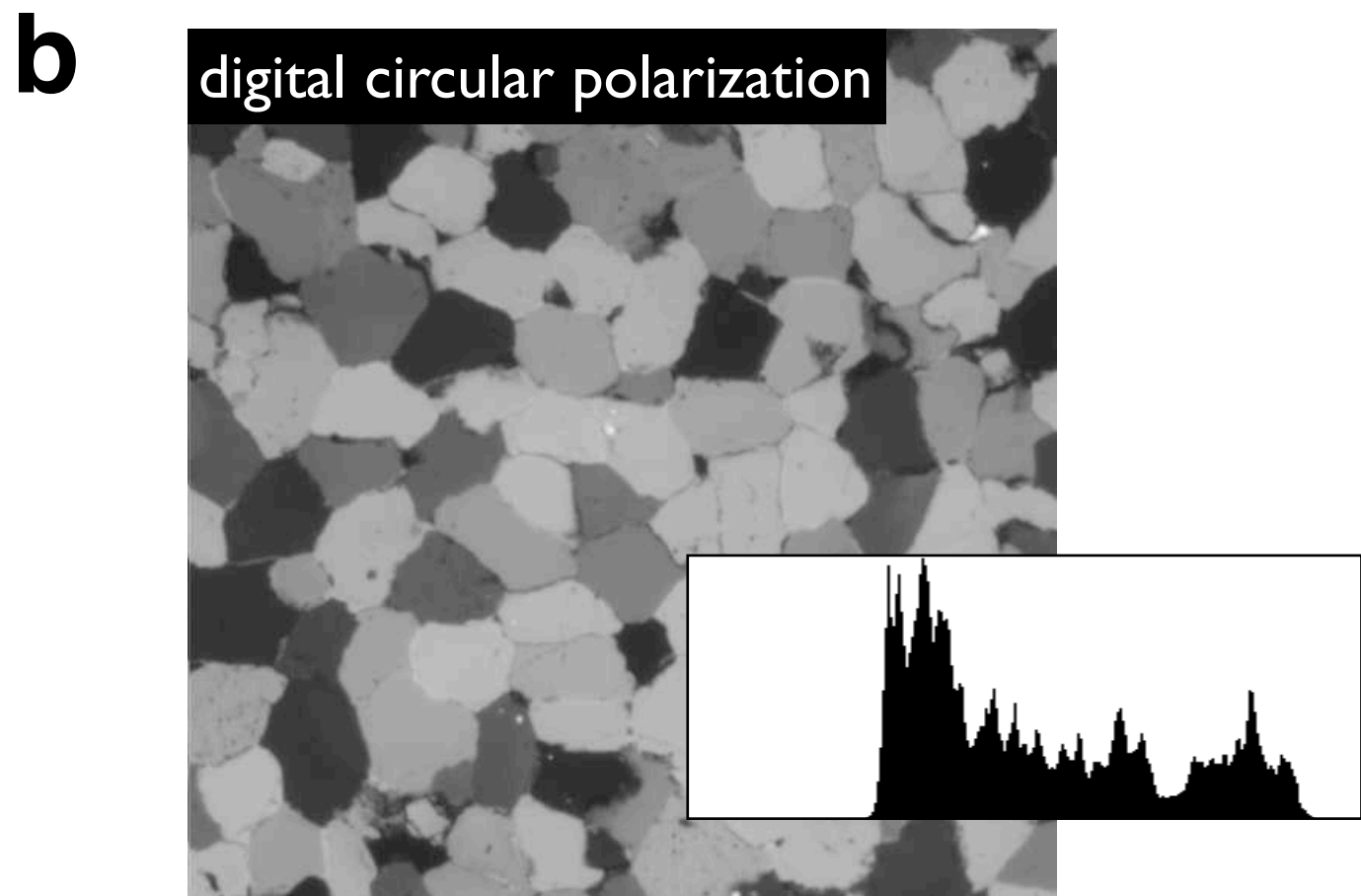
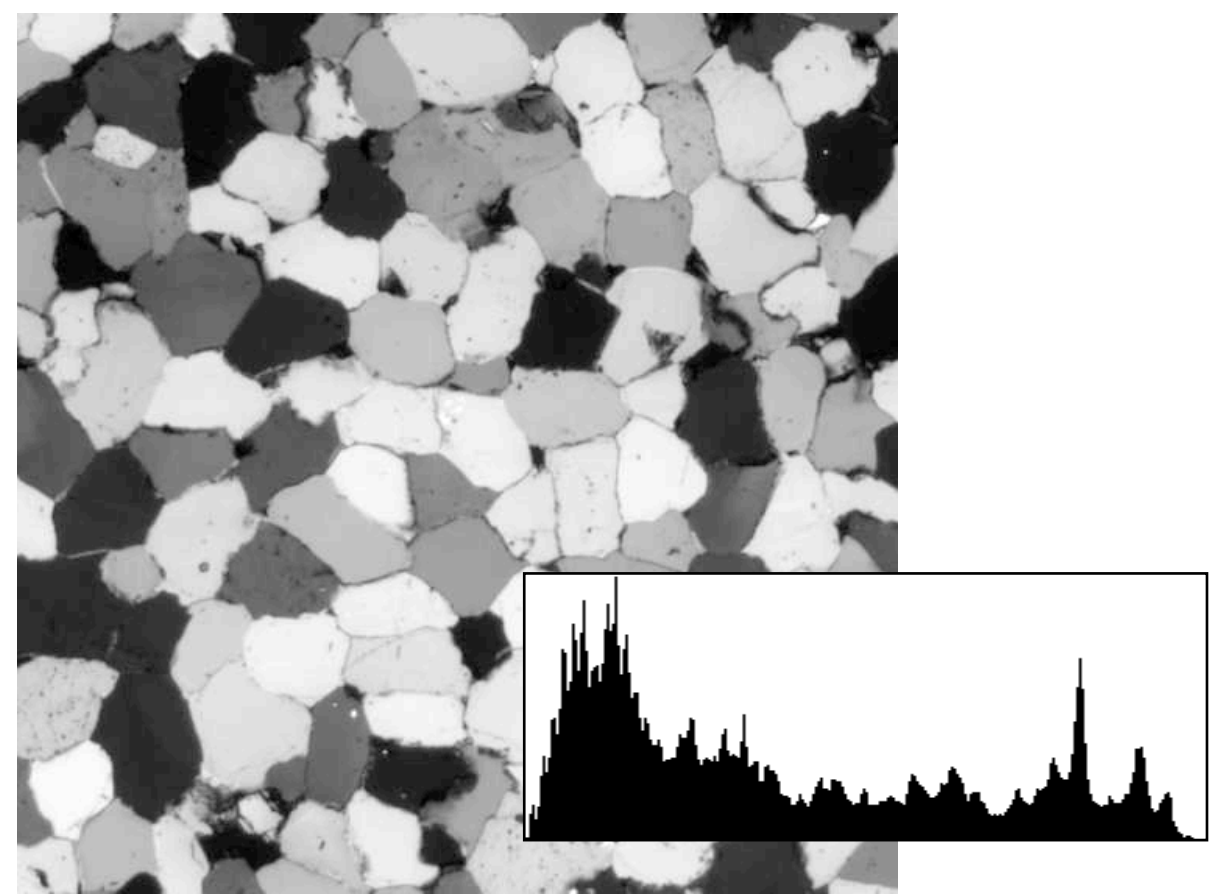
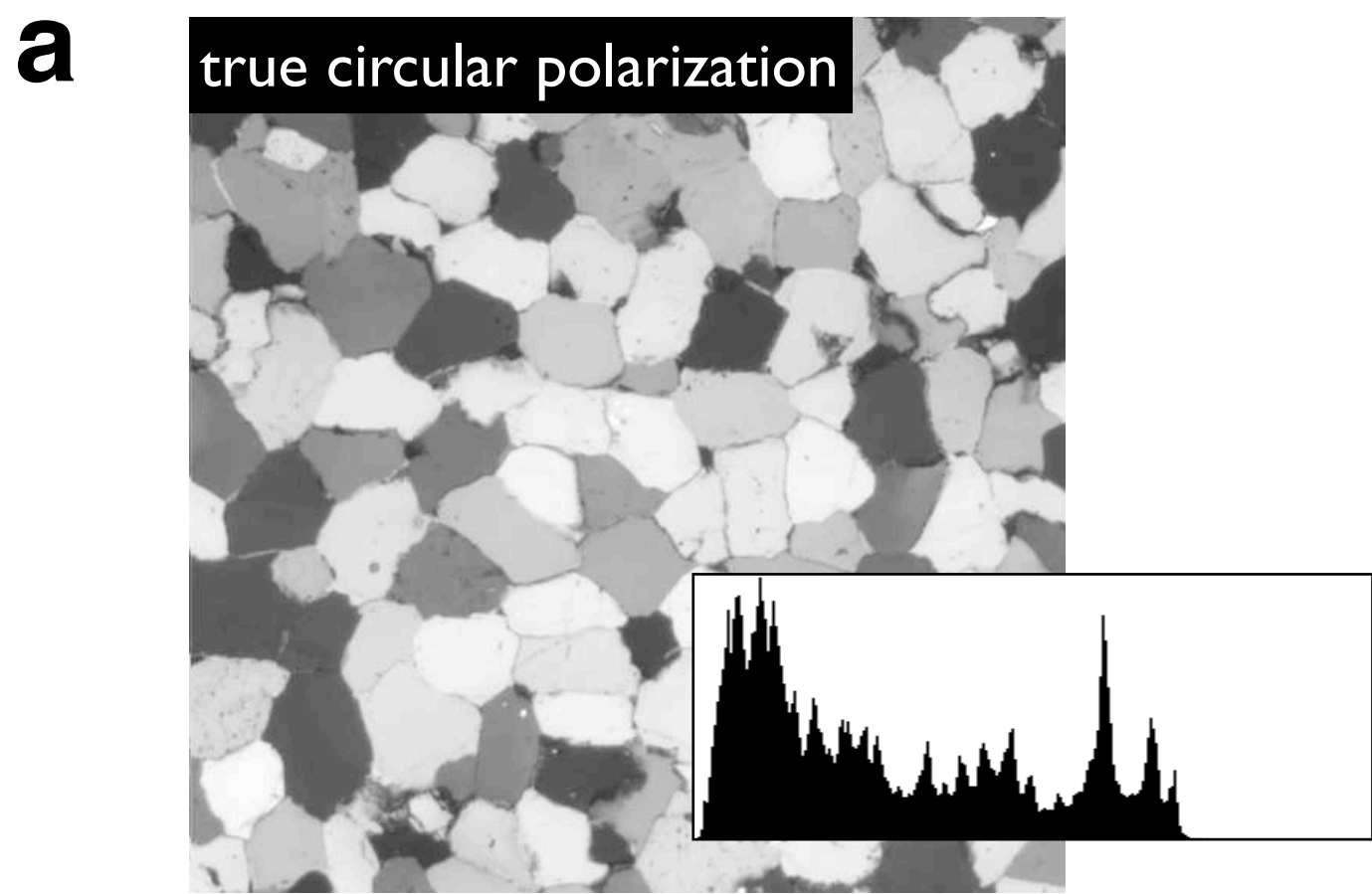
**Figure 22.14**

Circular polarization by digital means.

True circular polarization is obtained by using crossed polarizers and two quarter-wave plates (see Figure 22.9); it can also be obtained by adding nine cross polarized images at  $10^\circ$  rotation increments.

(a) For visualization, 9 conoscopic images of cross polarization are added to yield conoscopic image of circular polarization;

(b) superposition of nine cross polarized images to produce circular polarization.



**Figure 22.15**

Comparison of digital and true circular polarization.

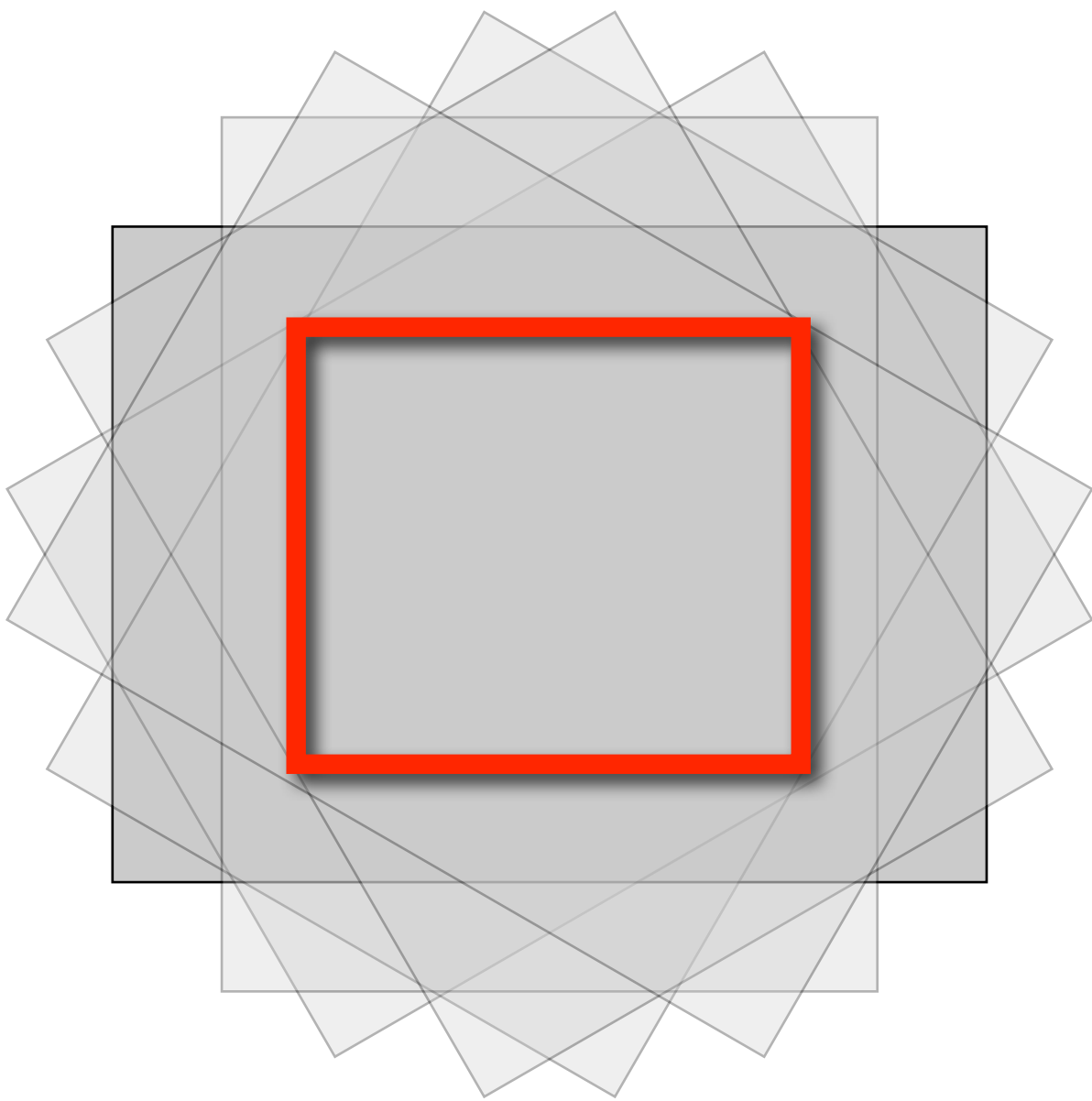
(a) True circular polarization obtained by using crossed polarizers and two quarter-wave plates;

(b) digital circular polarization obtained by adding nine cross polarized images at  $10^\circ$  rotation increments.

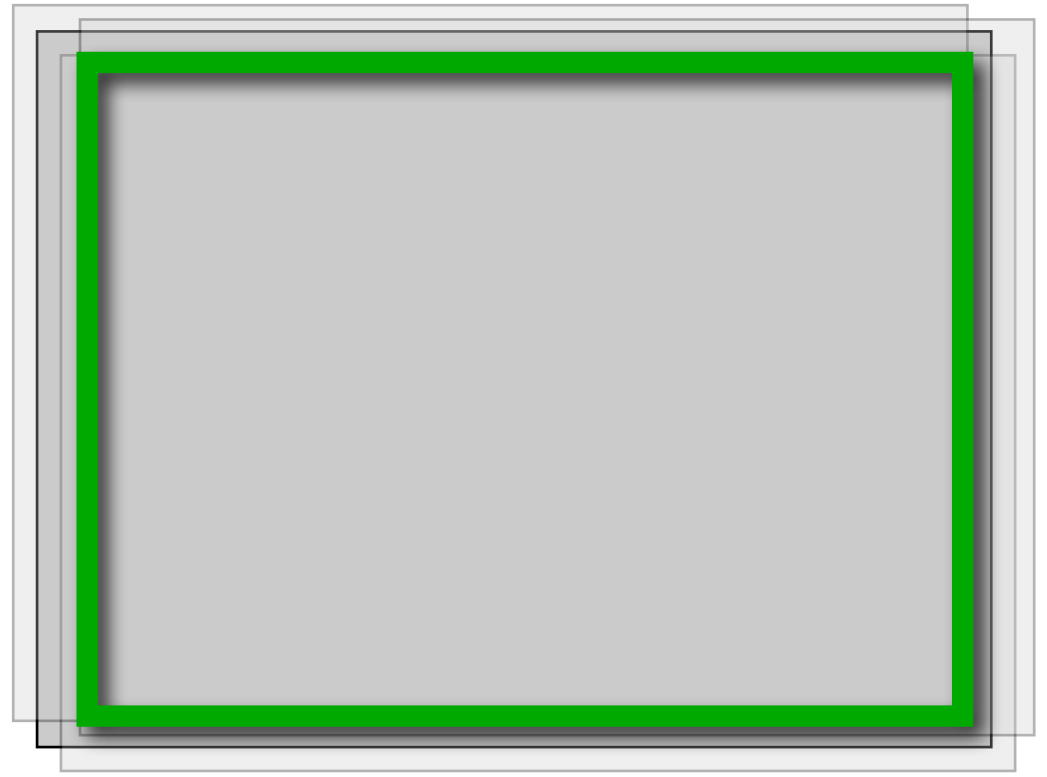
Left: originals; right: stretched to full contrast

Note reduced focus in (b) due to mismatch of rotated images.



**a**

1600 · 1200 → 900 · 700

**b**

1600 · 1200 → 1500 · 1100

**Figure 22.16**

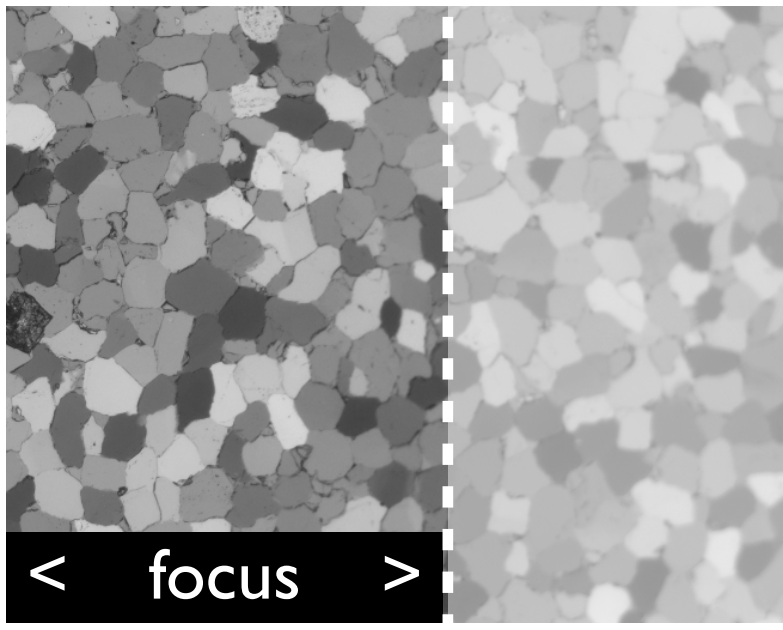
Modes of rotation.

Usable area depends on mode of rotation:

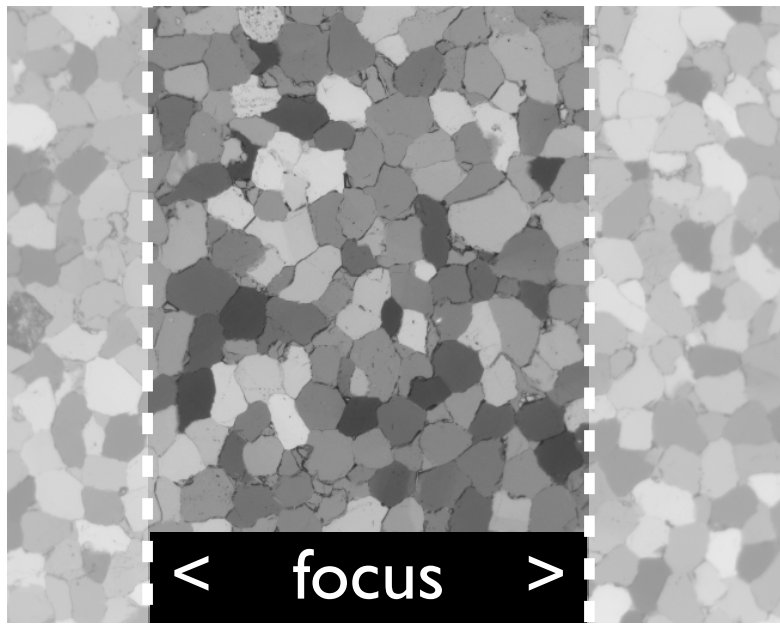
(a) rotation of thin section (CCW) - polarizers and wave plate remain fixed;

(b) rotation of polarizers and wave plate (CLW) - thin section remains fixed.

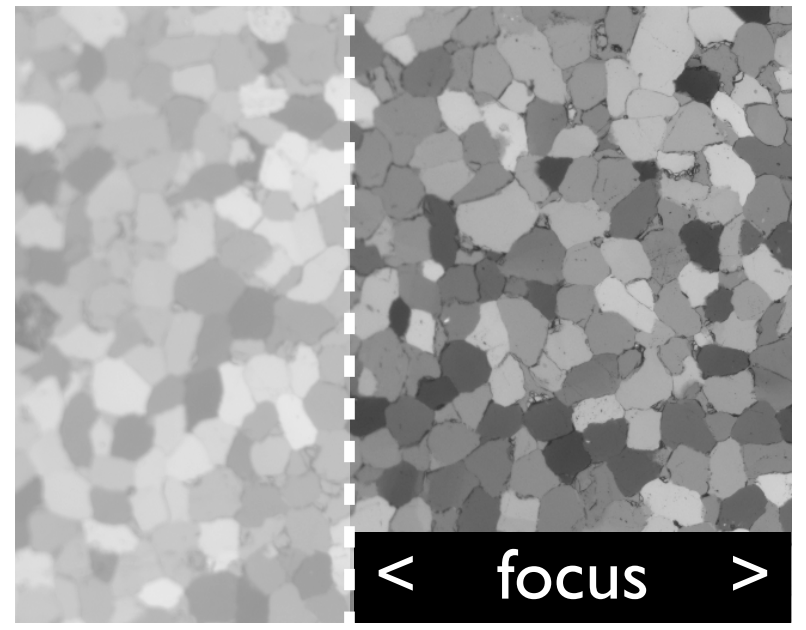
eup 1



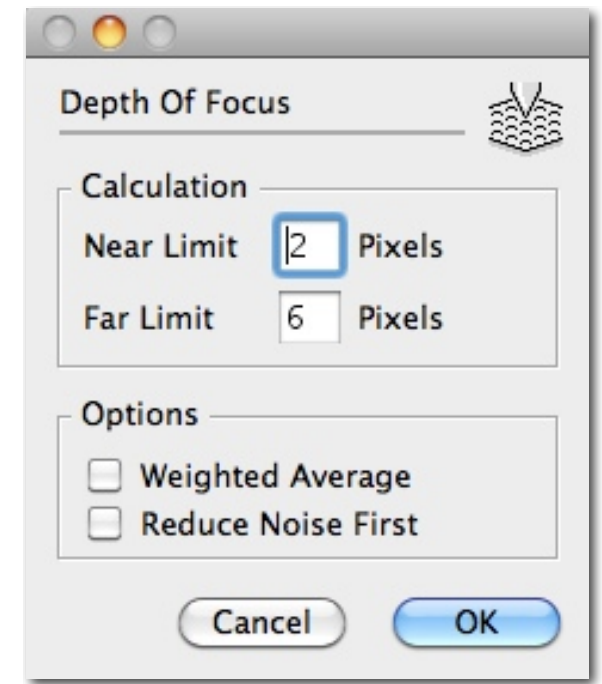
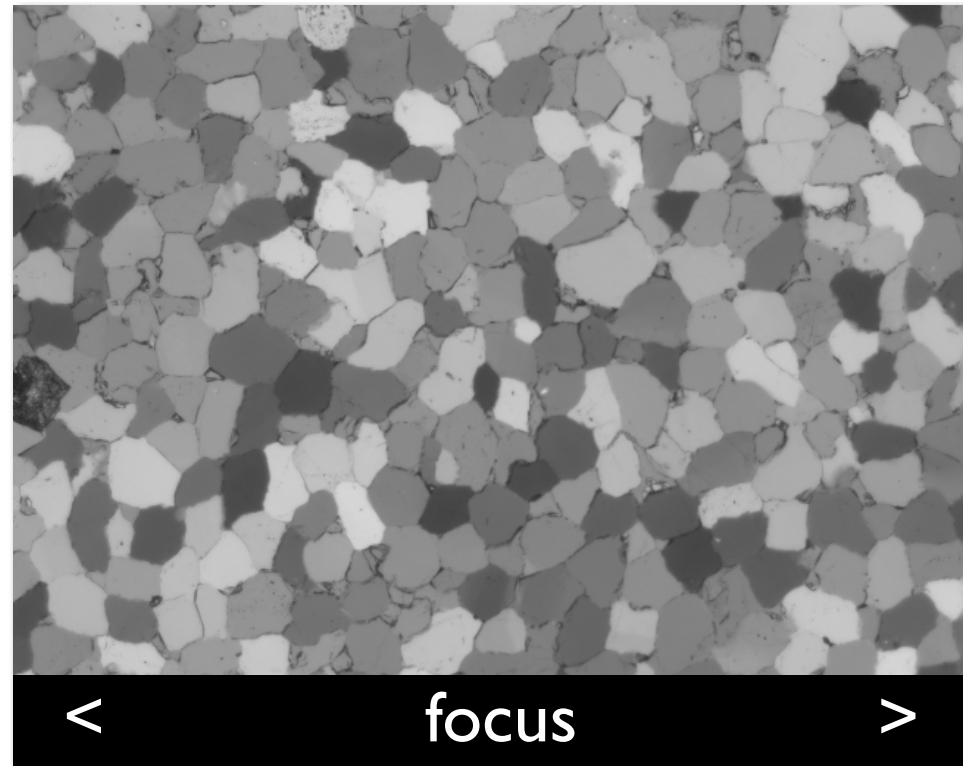
eup 2



eup 3



composite

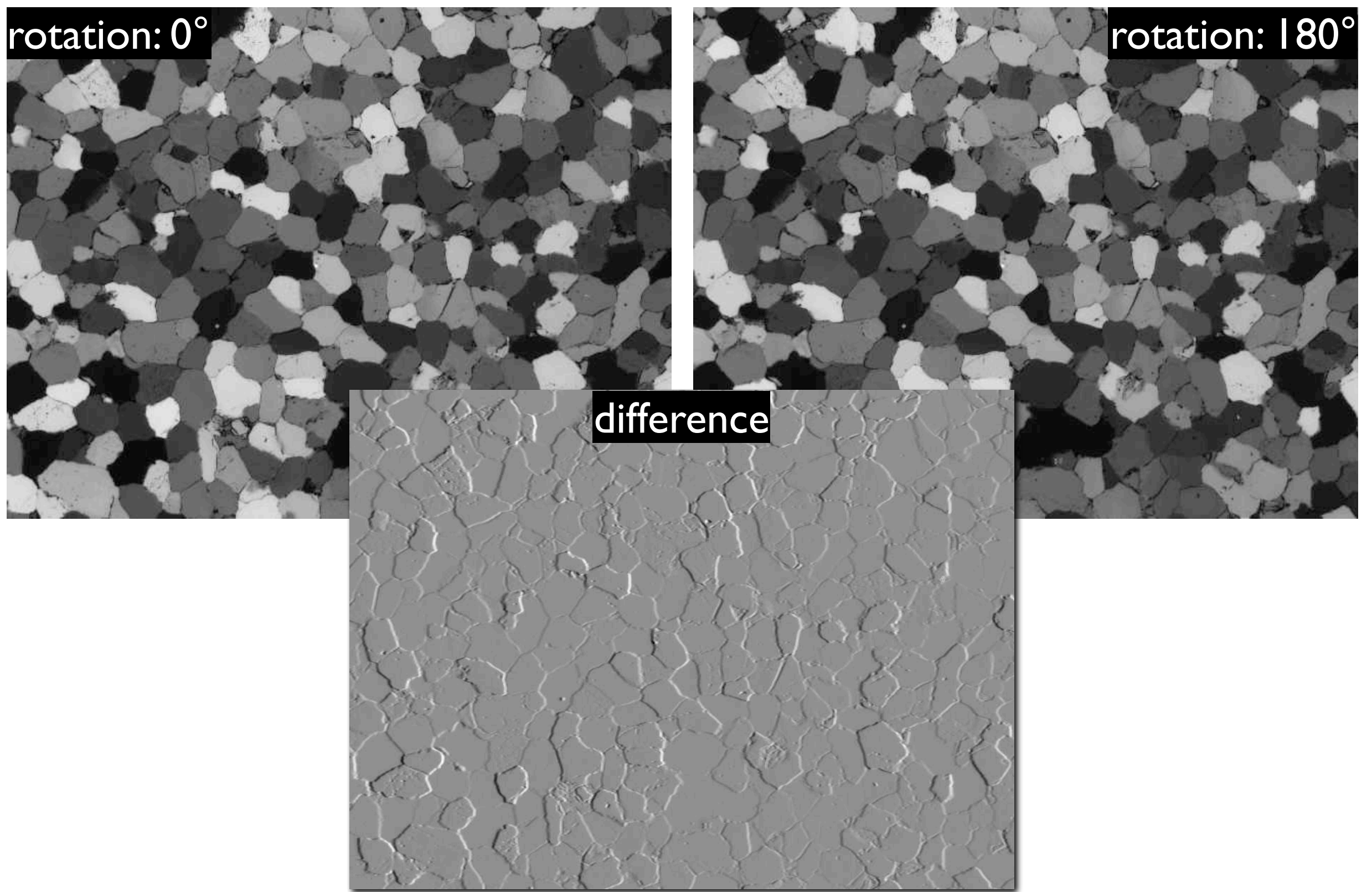


**Figure 22.17**

Composites of tilt images.

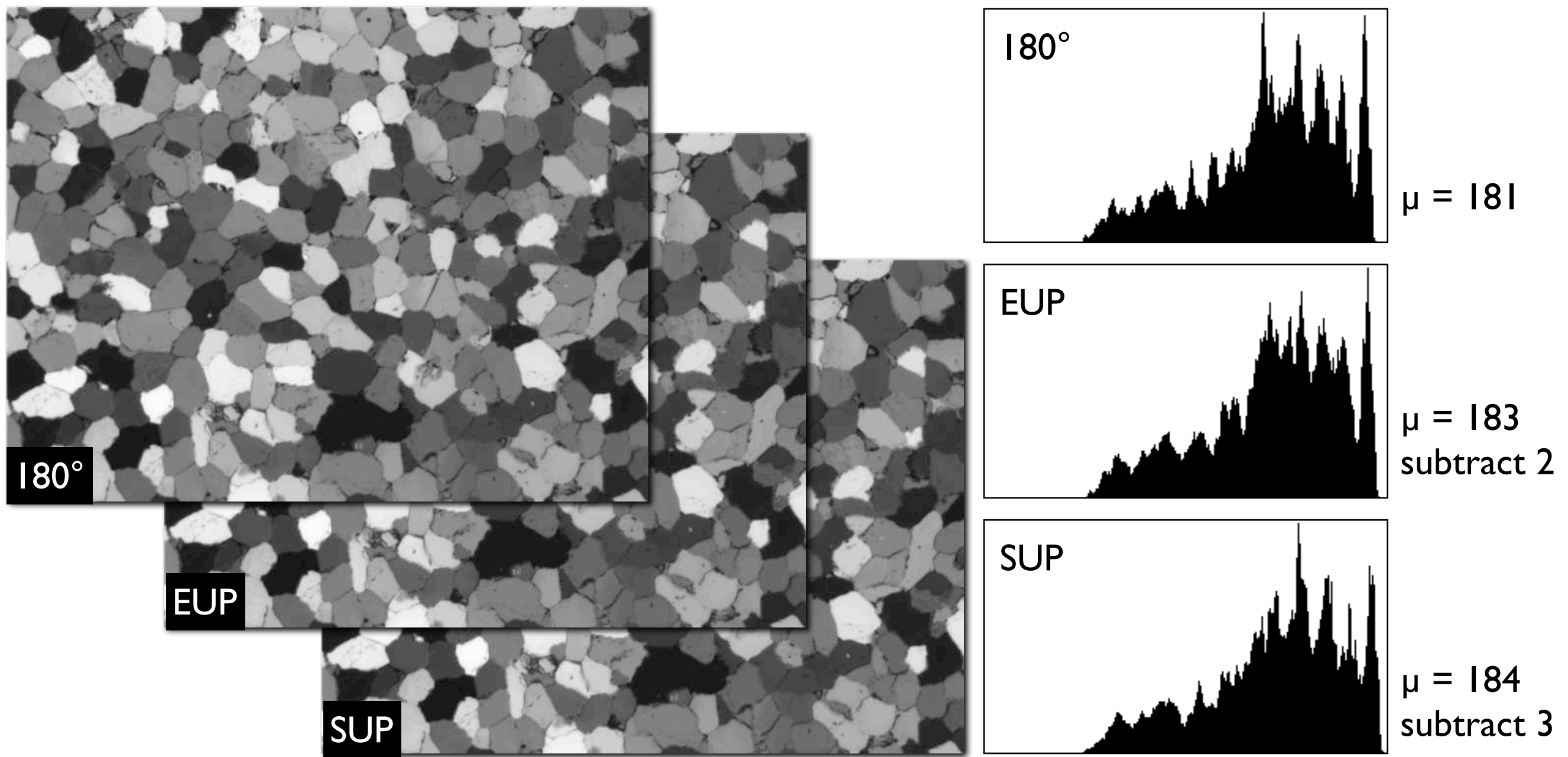
Tilt images have to be assembled from images taken at different distances from the objective. Three partially focused images are shown on top, merged composite at the bottom; focused part of images is indicated. In lower right, the settings of the 'Depth of Focus...' command in the Stacks menu.





**Figure 22.18**

Differential wandering of image points under crossed polarizing conditions. Two rotation images (as in Figure 22.11) before and after rotation of crossed polarizers and wave plate about 180°. Difference image shows apparent relative shift of grains as steps; amount of shift is function of orientation of optic axis with respect to microscope axis.

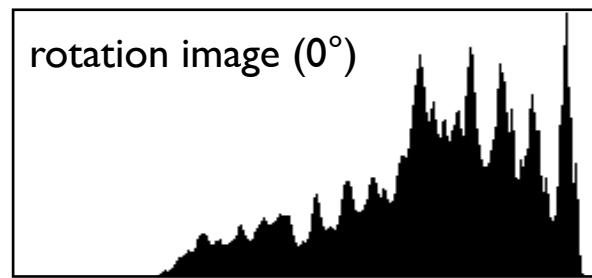
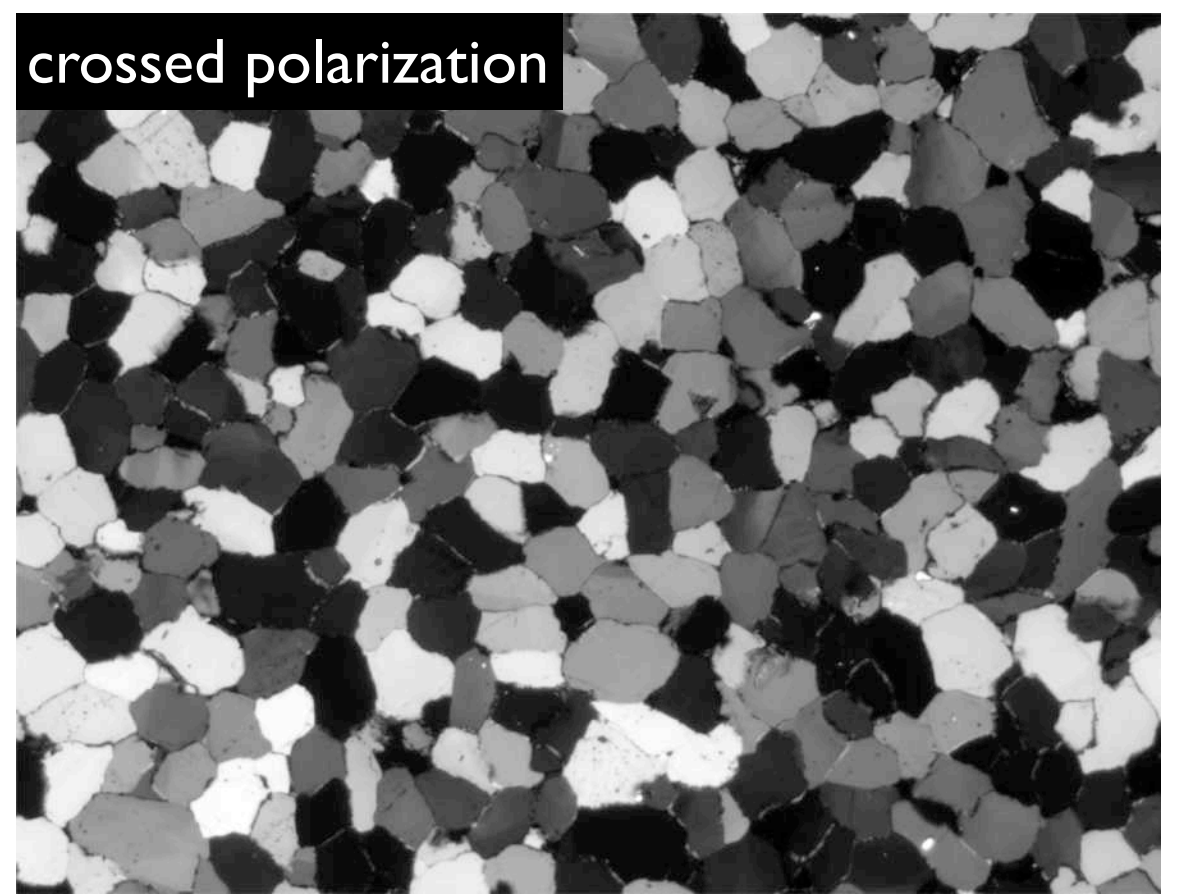
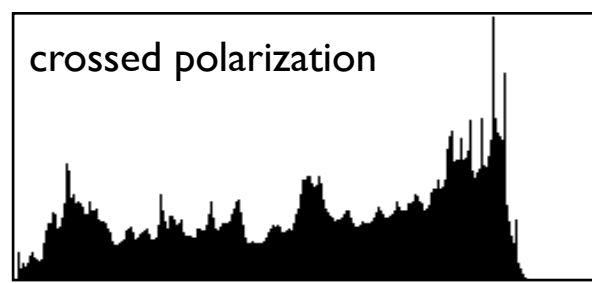
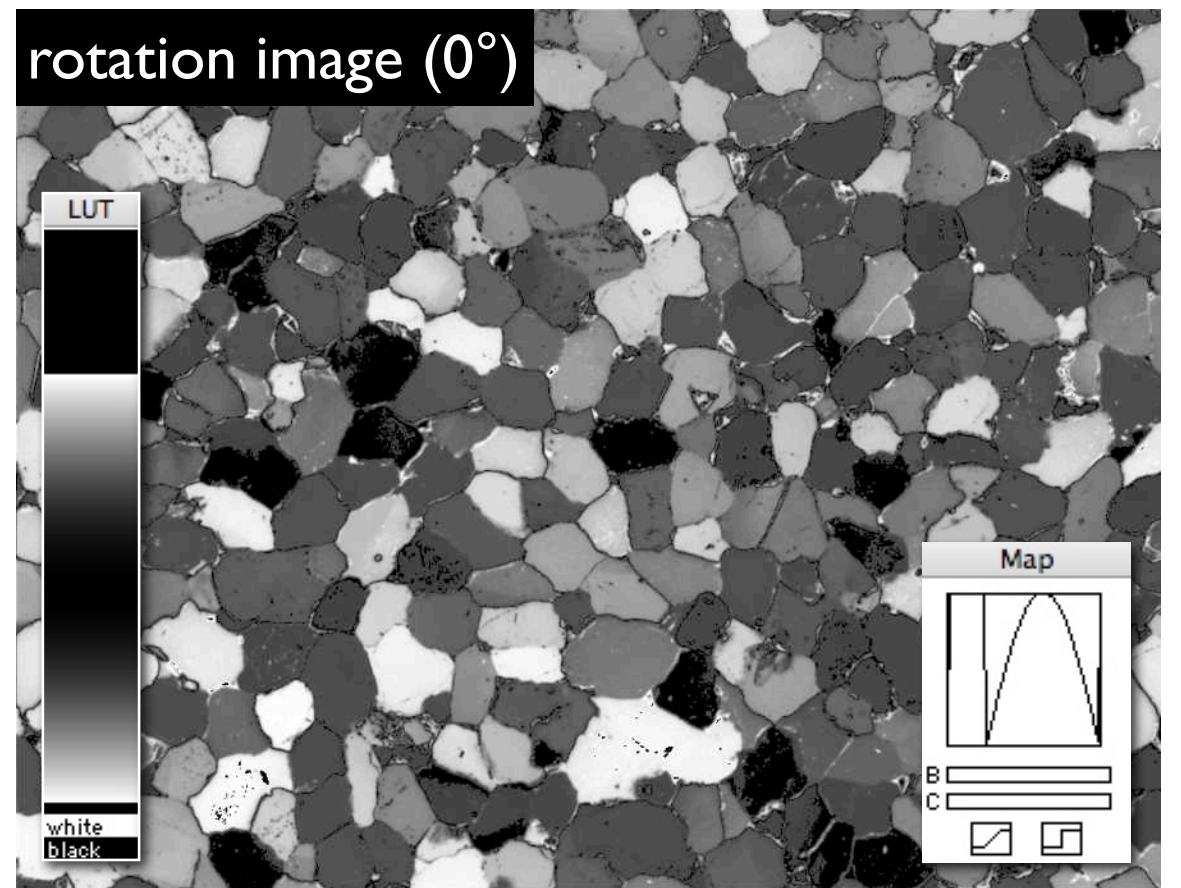
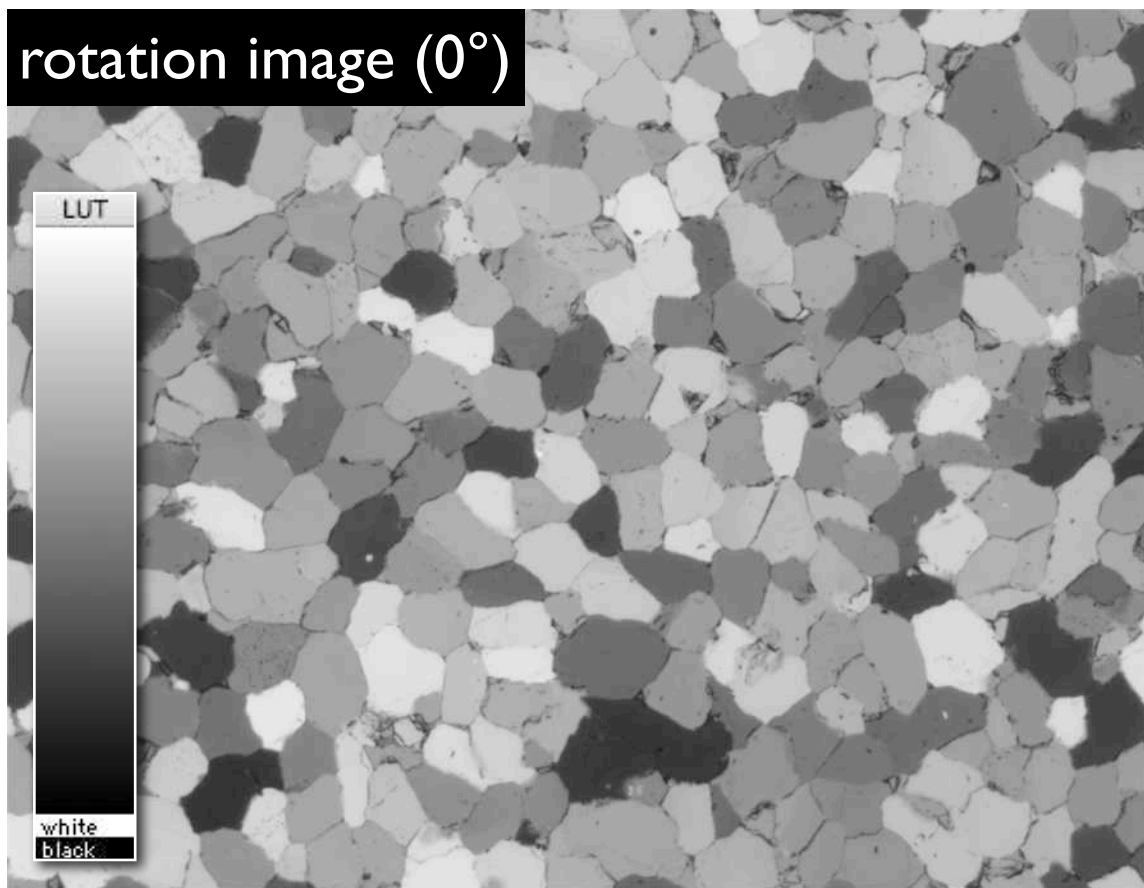


**Figure 22.19**

Checking average densities.

The average density of the last rotation image (180°) and the tilt images (EUP and SUP) can be different due to sharp textures or changes of lighting conditions as occur during re-focusing.



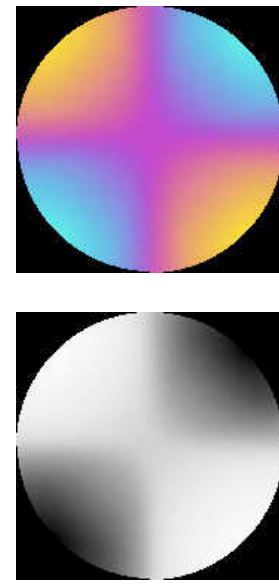
**a****b****Figure 22.20**

Comparing rotation images to cross polarization.

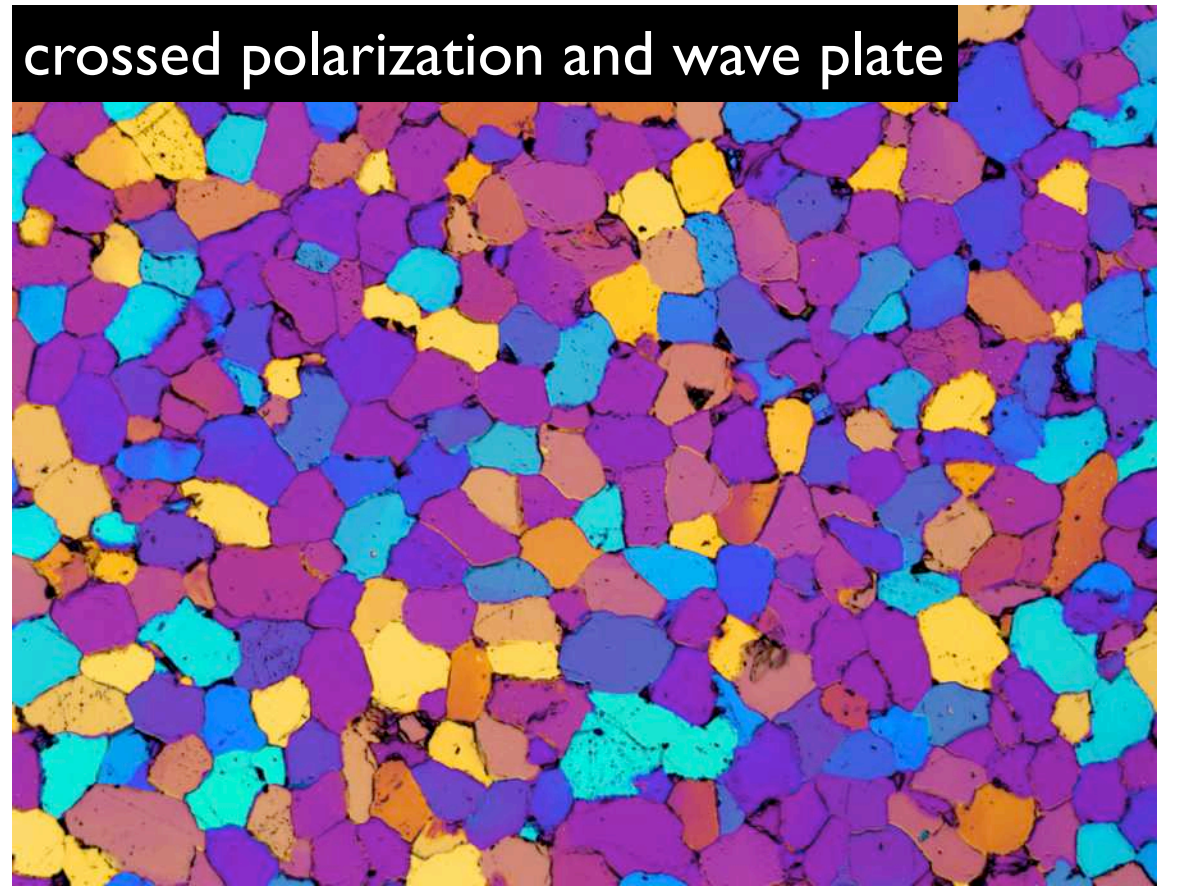
(a) Cross polarized image; histogram to the left;

(b) left: rotation image with histogram above; right: same image with special look-up table (LUT) designed to imitate the looks of cross polarization; LUT and Map are shown.

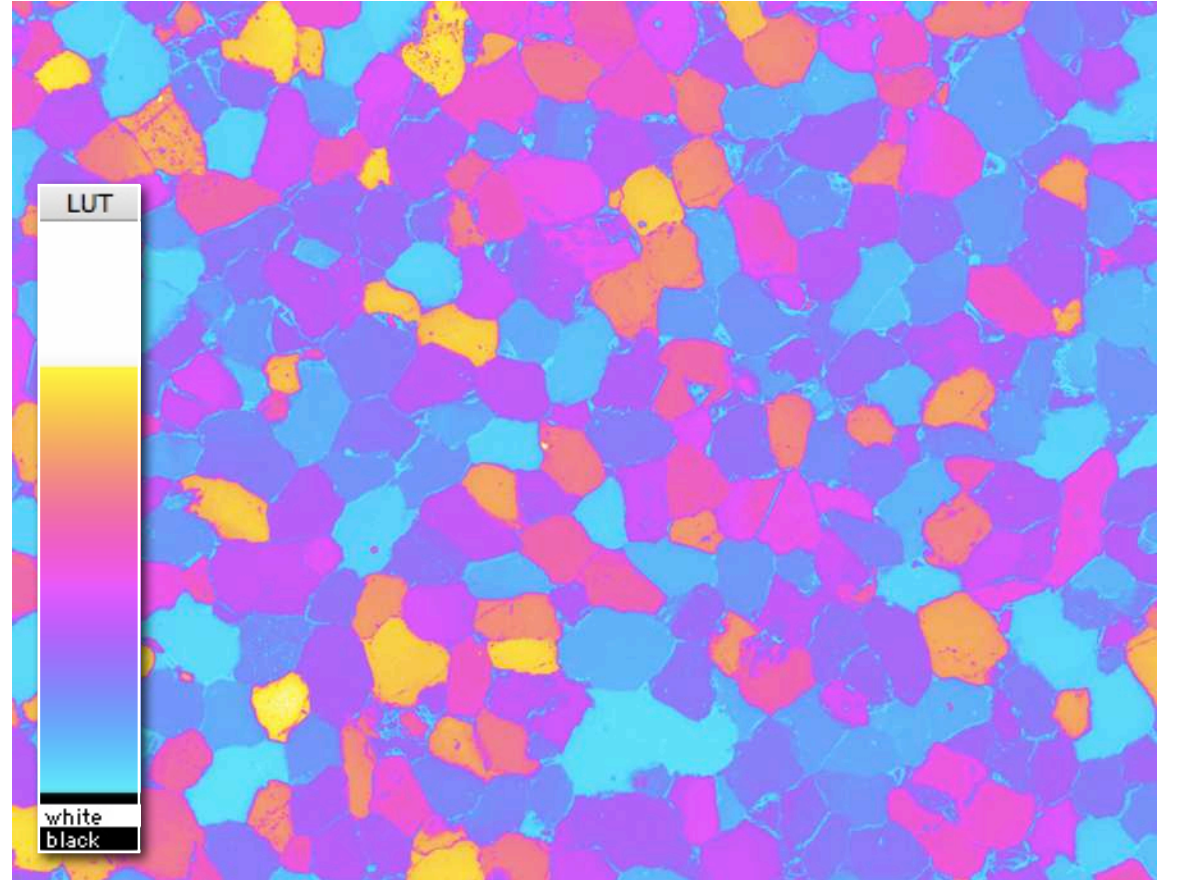
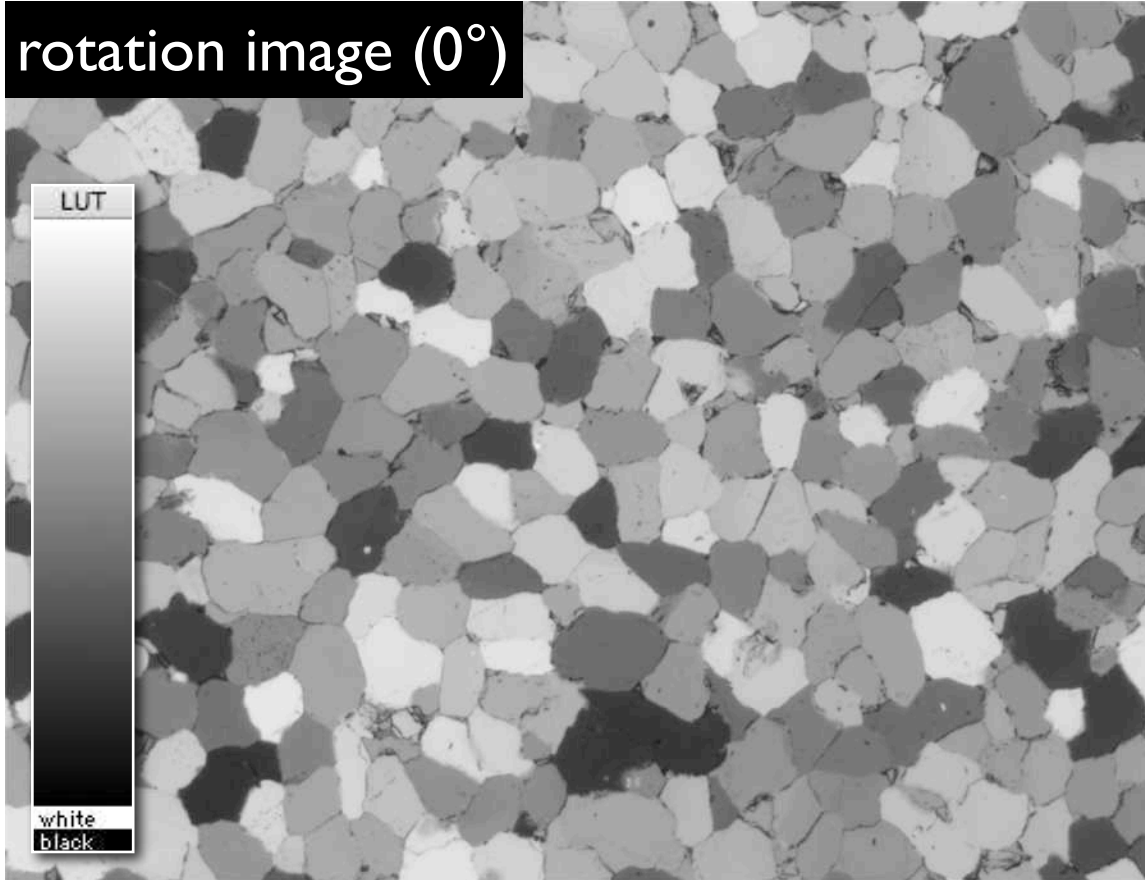


**a**

crossed polarization and wave plate

**b**

rotation image (0°)

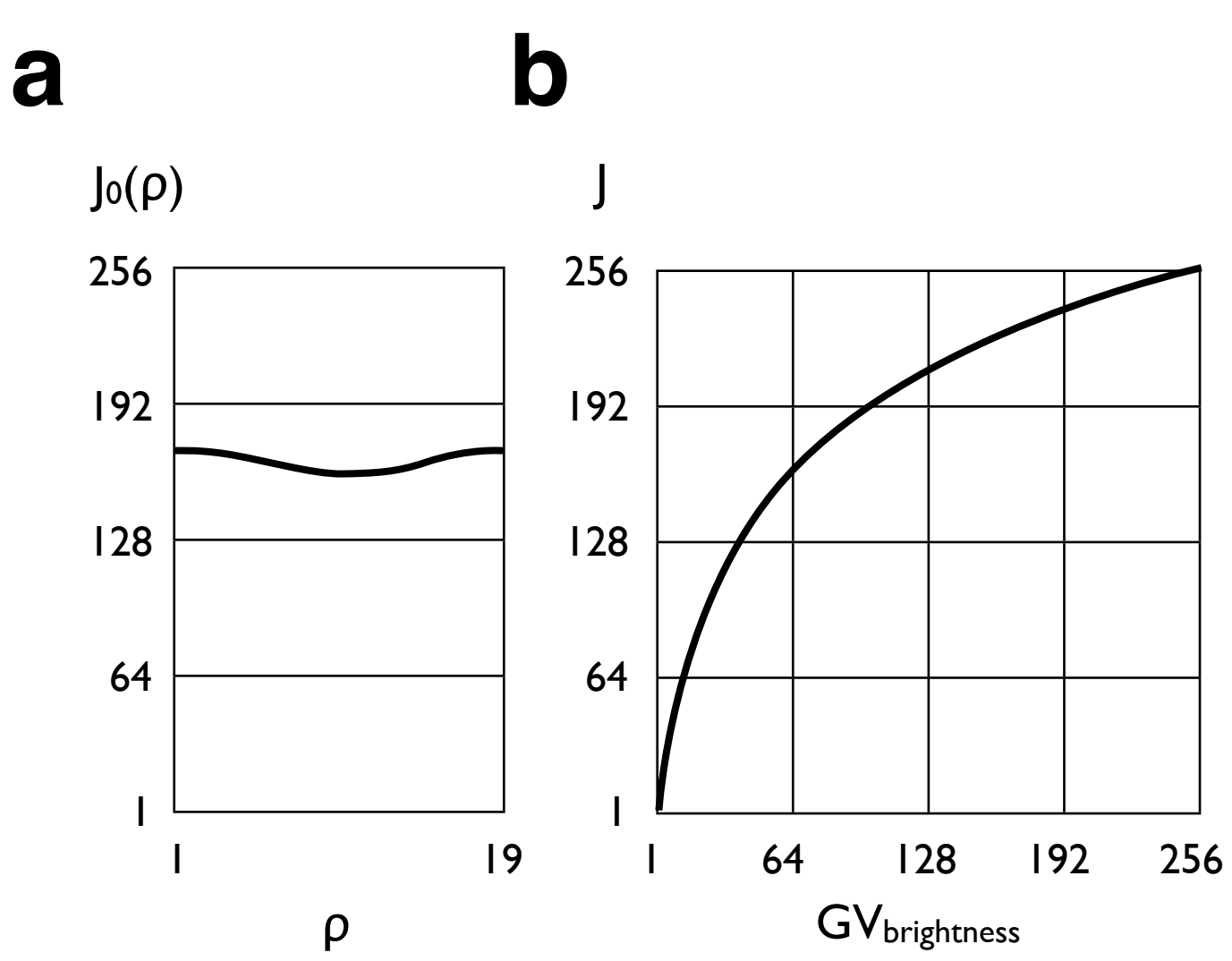
**Figure 22.21**

Comparing rotation images to cross polarization with wave plate.

(a) Image taken under cross polarized conditions with wave plate inserted with conoscopic image to the left;

(b) left: rotation image with corresponding conoscopic image above; right: same image with look-up table designed to imitate the looks of cross polarization with wave plate inserted.



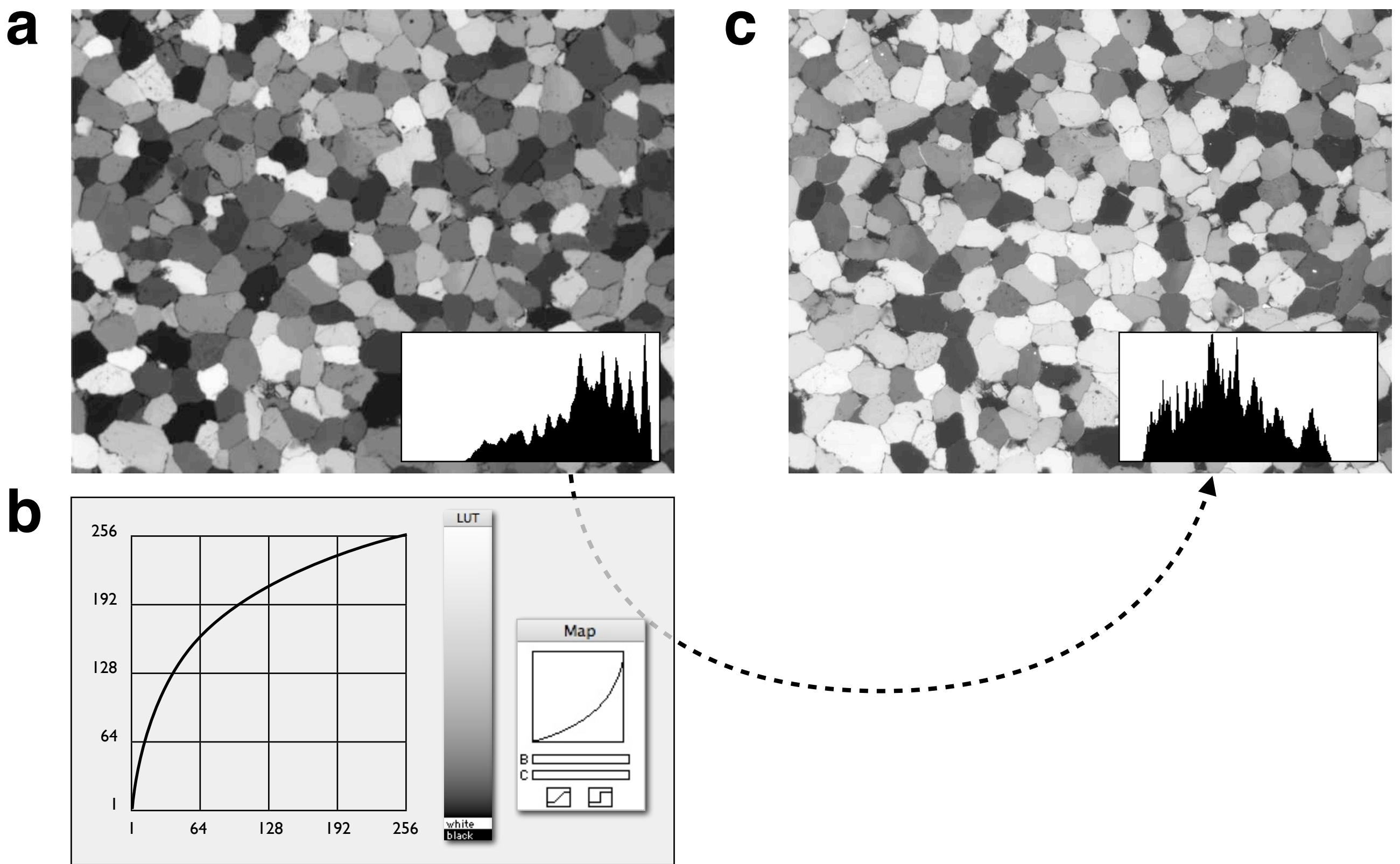


**Figure 22.22**

Converting recorded gray values to linear intensities.

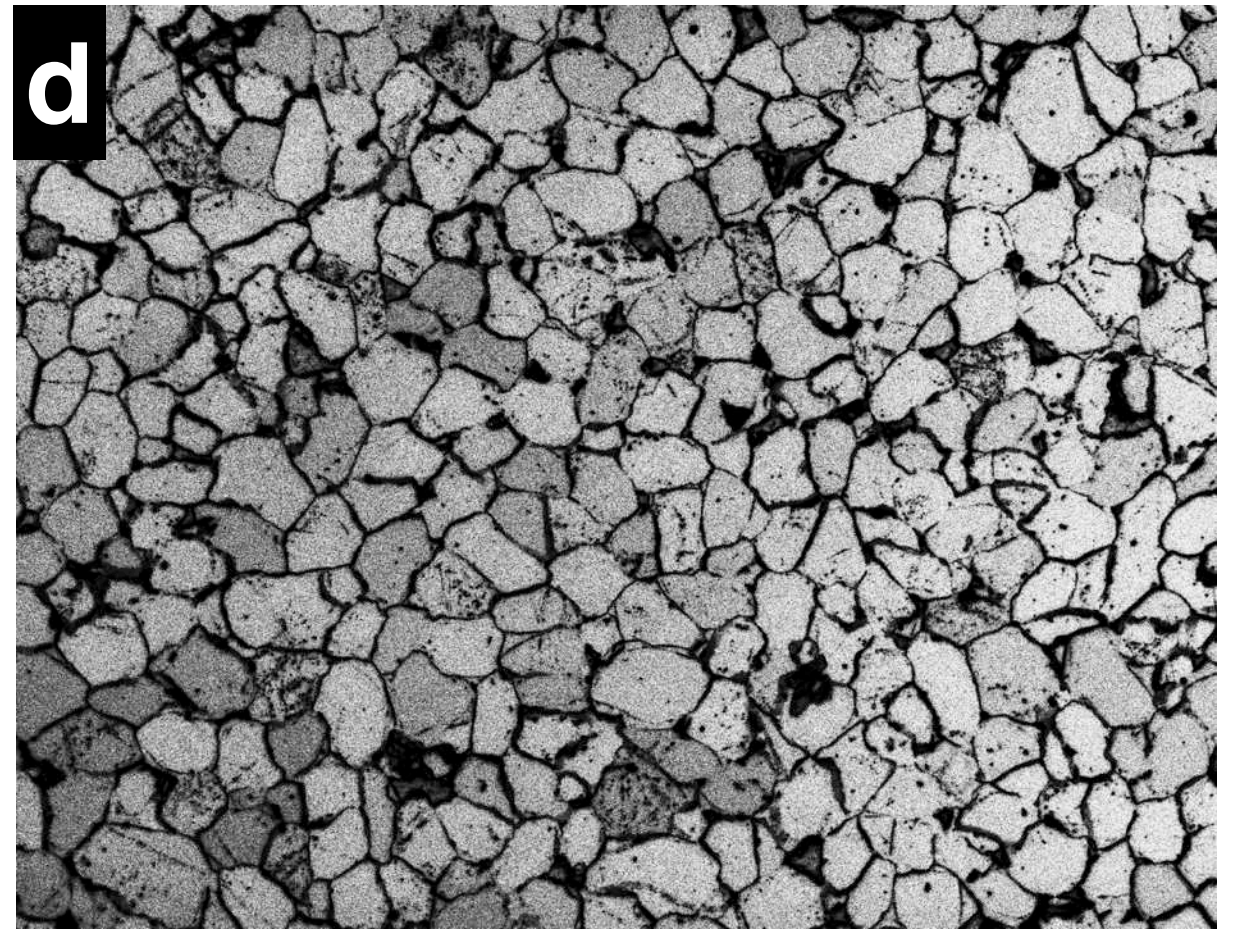
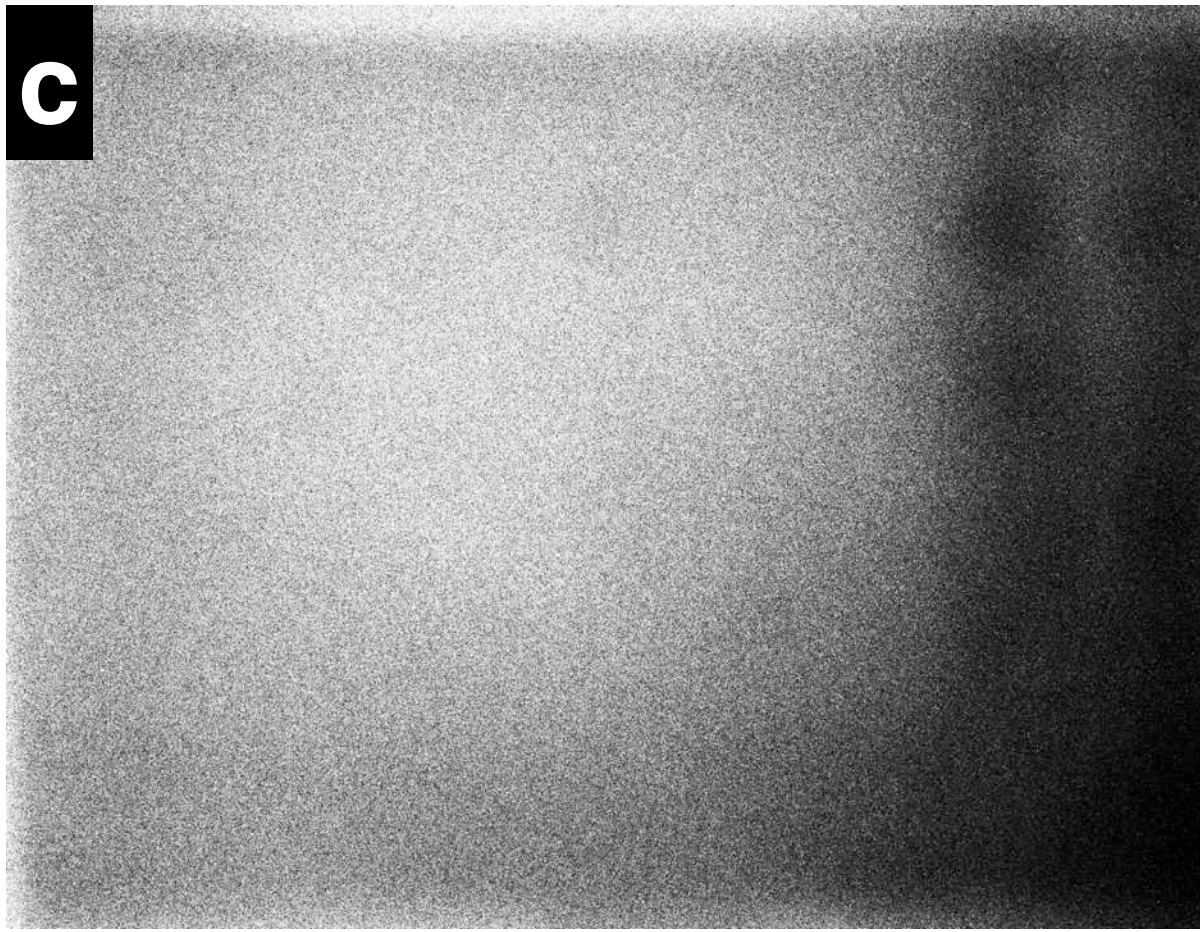
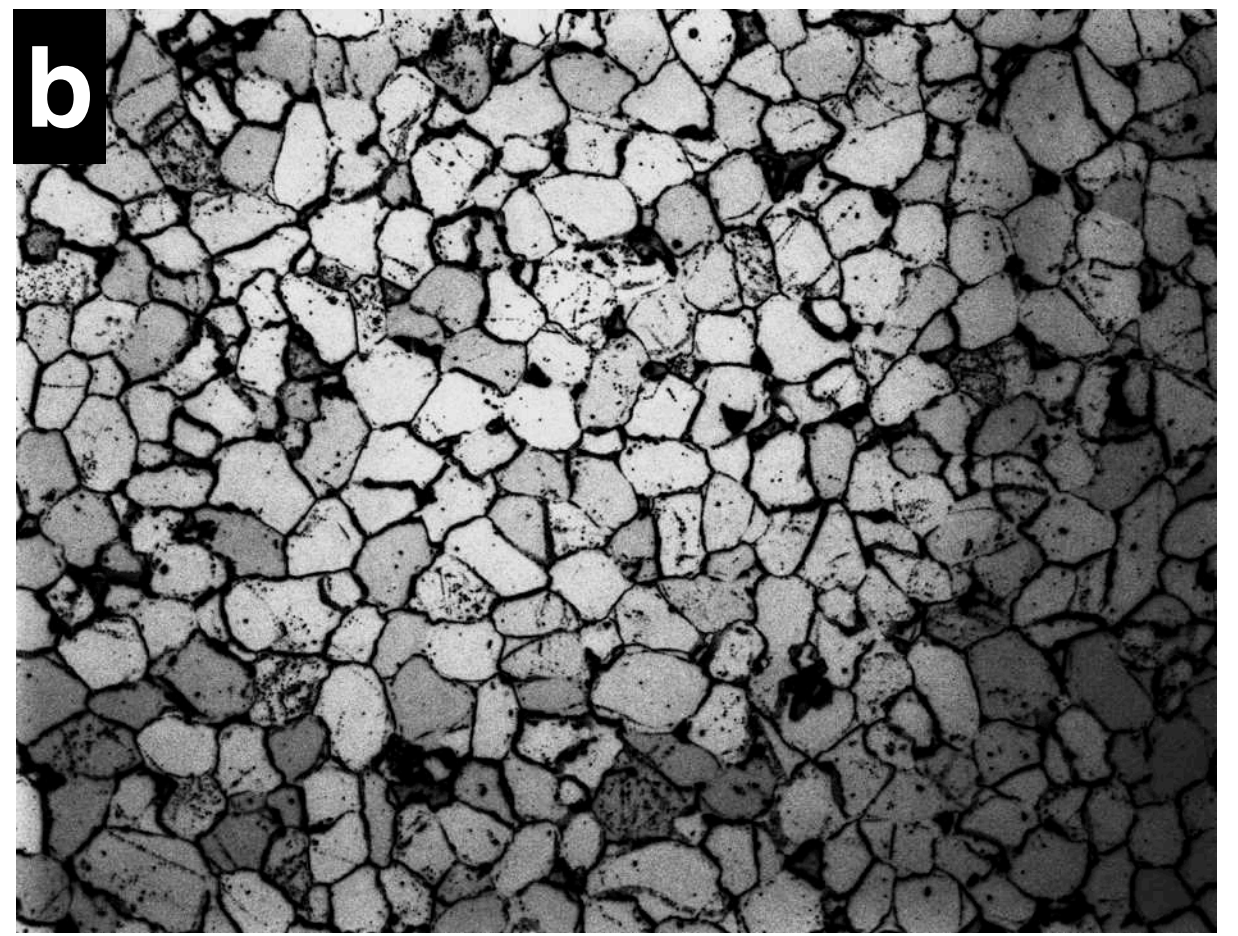
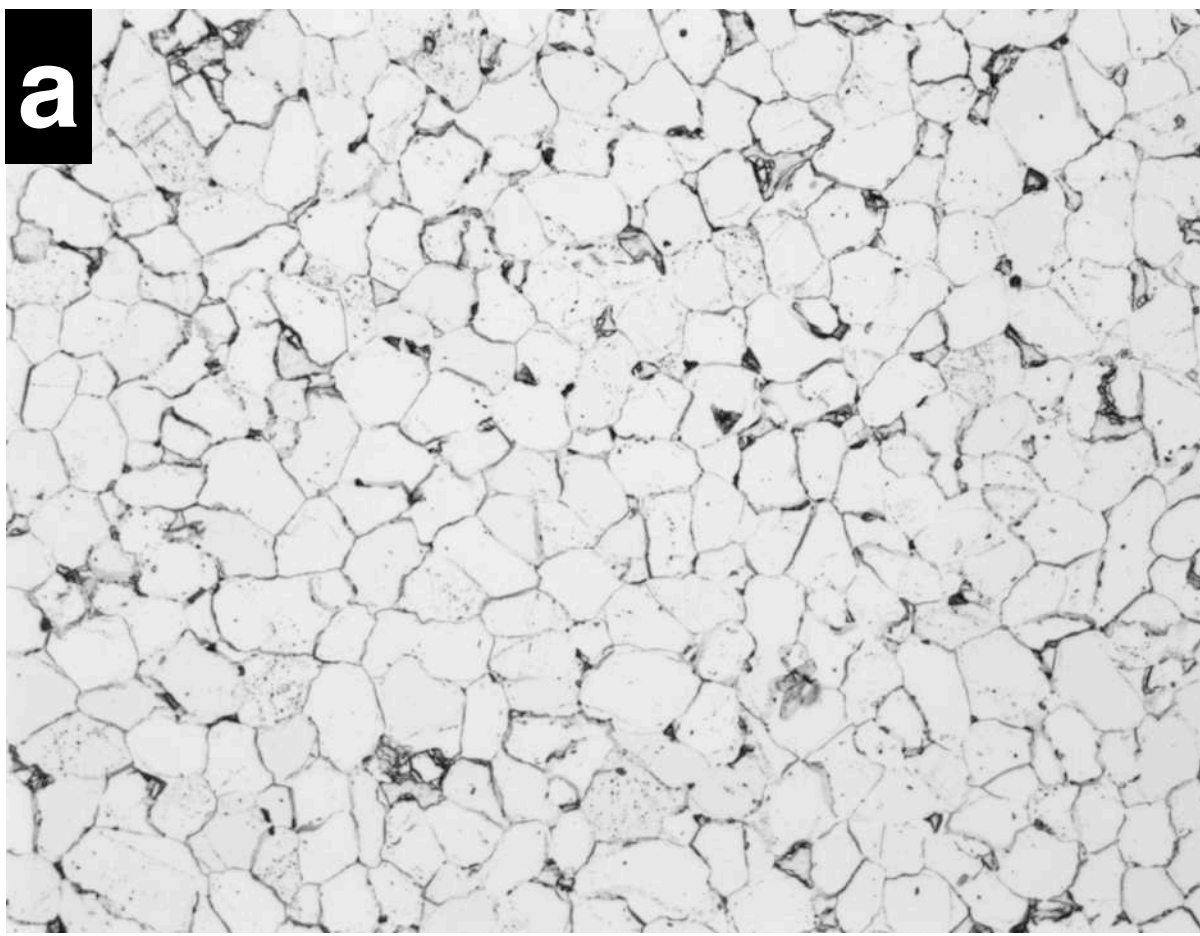
(a) Example of variations of incoming light intensity caused by rotating polarizers; 19 value for  $\rho = 0^\circ$  to  $180^\circ$  for  $10^\circ$  increments;

(b) example of camera calibration used to convert logarithmic gray values to linear intensities.



**Figure 22.23**  
 Look-up tables for gray value - intensity conversion.  
 (a) Rotation image as recorded with histogram;  
 (b) camera LUT (left) is converted Image SXM LUT (right);  
 (c) image (a) and histogram after application of (b).





**Figure 22.24**

Subtraction of background image.

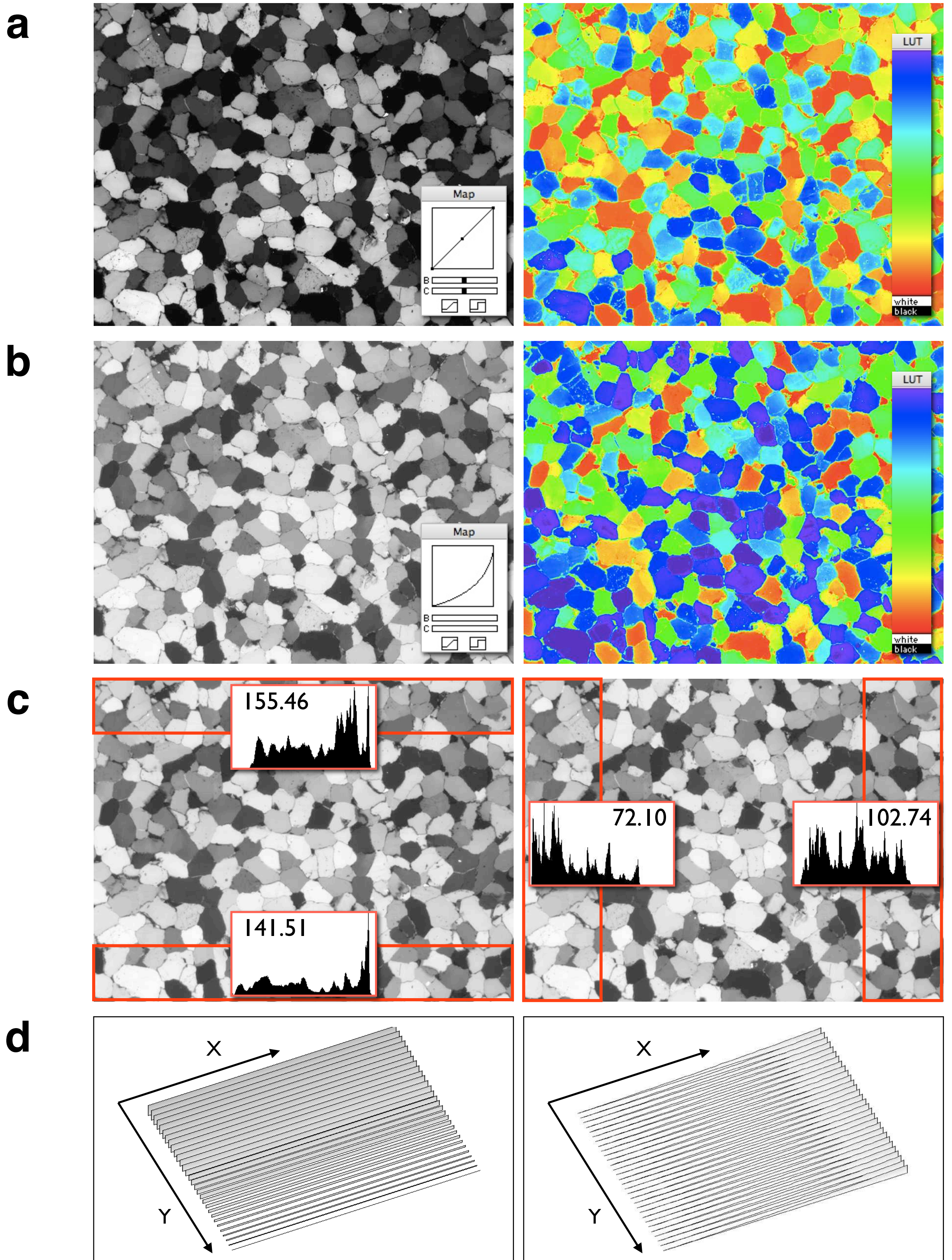
(a) Un-polarized image;

(b) same as (a) with histogram equalization to highlight uneven background;

(c) background with histogram equalization;

(d) background subtracted from (a), result shown with histogram equalization.





**Figure 22.25**

Check for section thickness.

Color LUT ('Rainbow' in Color Tables menu) used to highlight trend of gray values (GV).

(a) Circular polarized image as grayscale (left), and with color LUT (right);

(b) same as (a) after application of camera calibration.

Note: more blue grains = slight decrease of GV towards bottom left = slight increase of brightness = slight increase of section thickness.

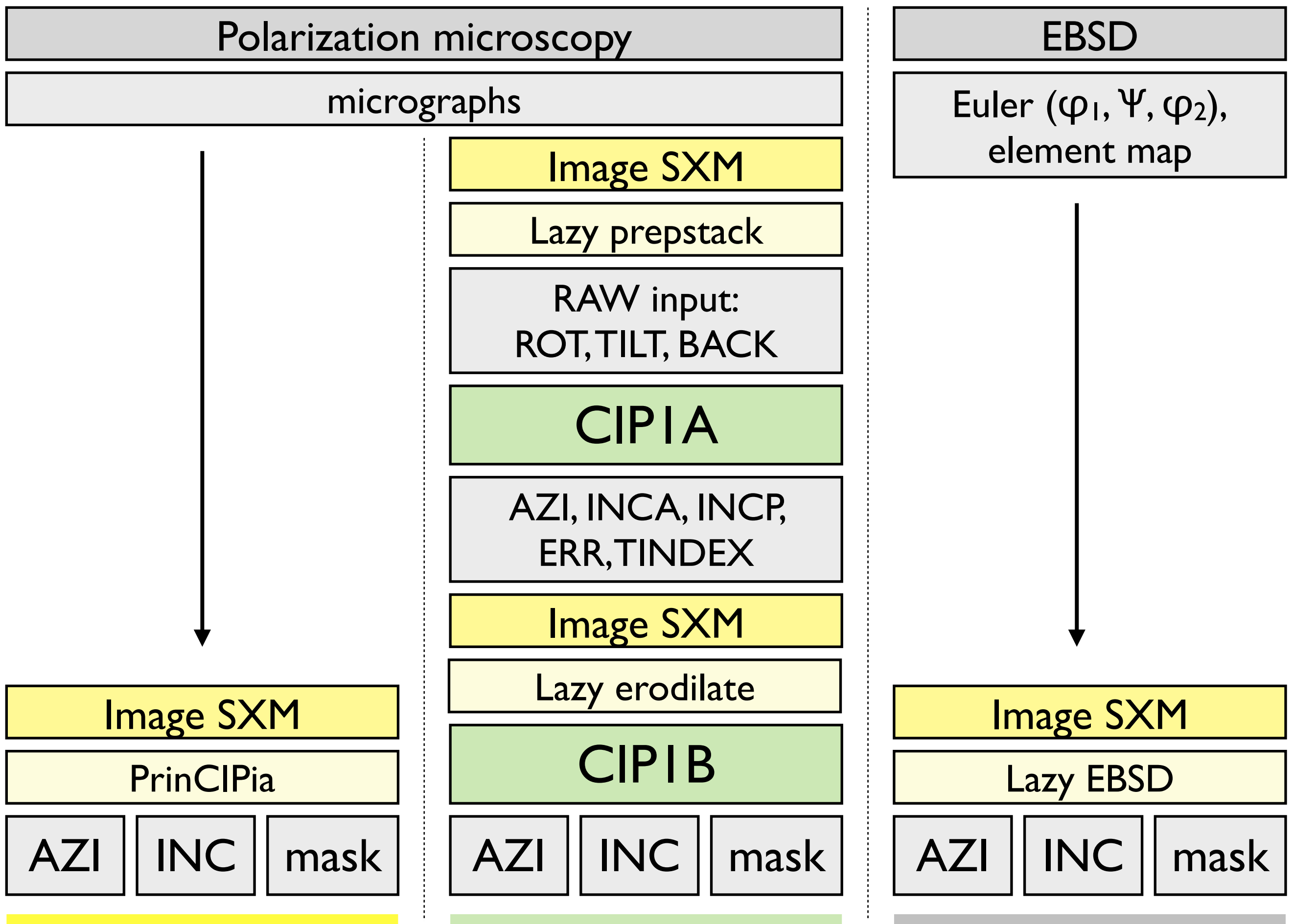
(c) Using Lazy lighting macro: determine histogram in top, bottom, left and right 1/6 of image;

(d) wedges representing gray values that are subtracted (= section thickness that is added) to correct thickness.

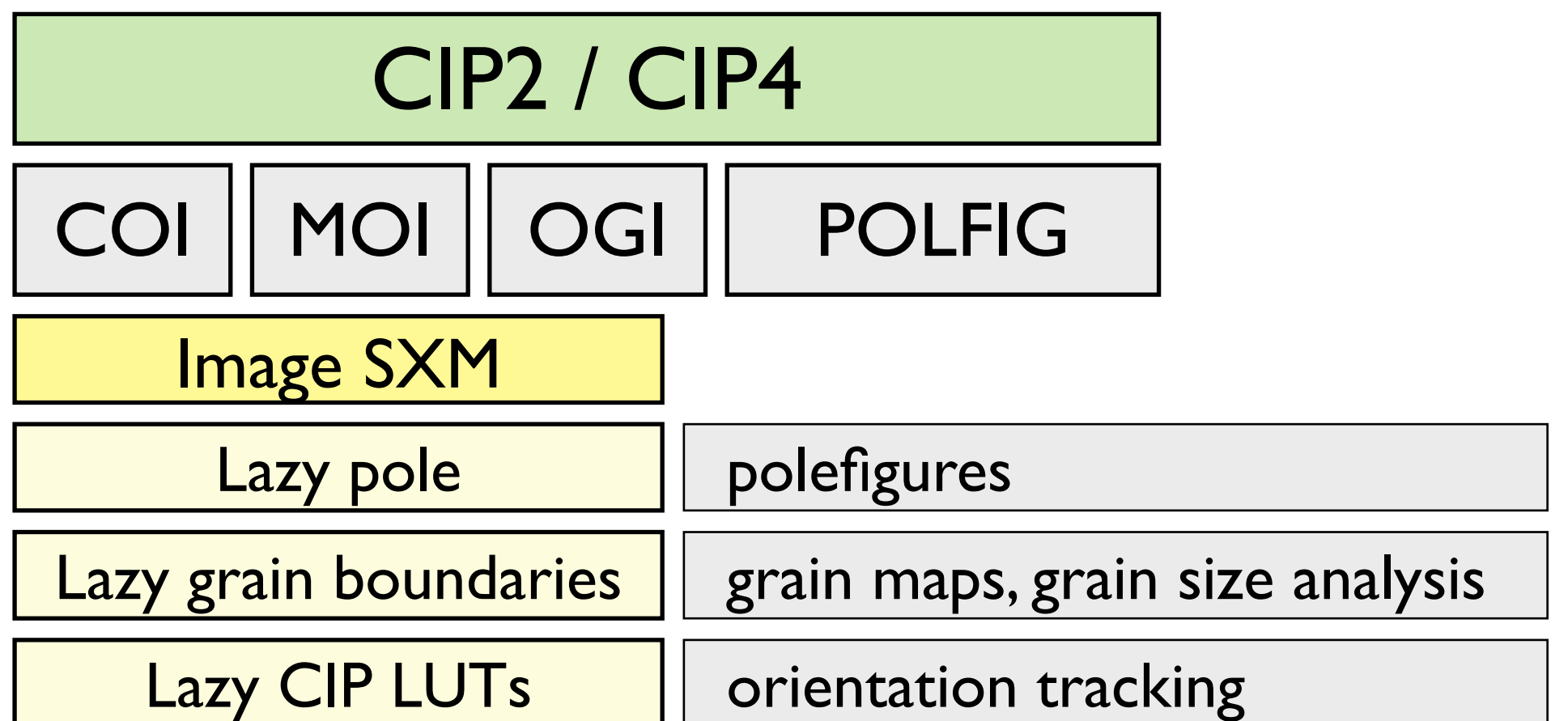


# CIP software (Fortran)

1



2



## **Software Box 22.1**

Flow chart for CIP software:

(1) Calculating the primary orientation images (AZI and INC).

CIP1A yields primary inclination images AZI, INCA and INCP (with  $0^\circ < \text{inclination} < 90^\circ$ ), a tilt index image, TINDEXT, and an error image, ERR.

CIP1B yields the full inclination file, (INC with  $0^\circ < \text{inclination} < 180^\circ$ ).

(2) Calculating derived orientation images (COI, MOI and OGI) and pole figures.

The primary input images (AZI, INC and mask) may come from CIP1 (green), Image SXM (yellow) or electron back scatter diffraction (EBSD) (dark grey).

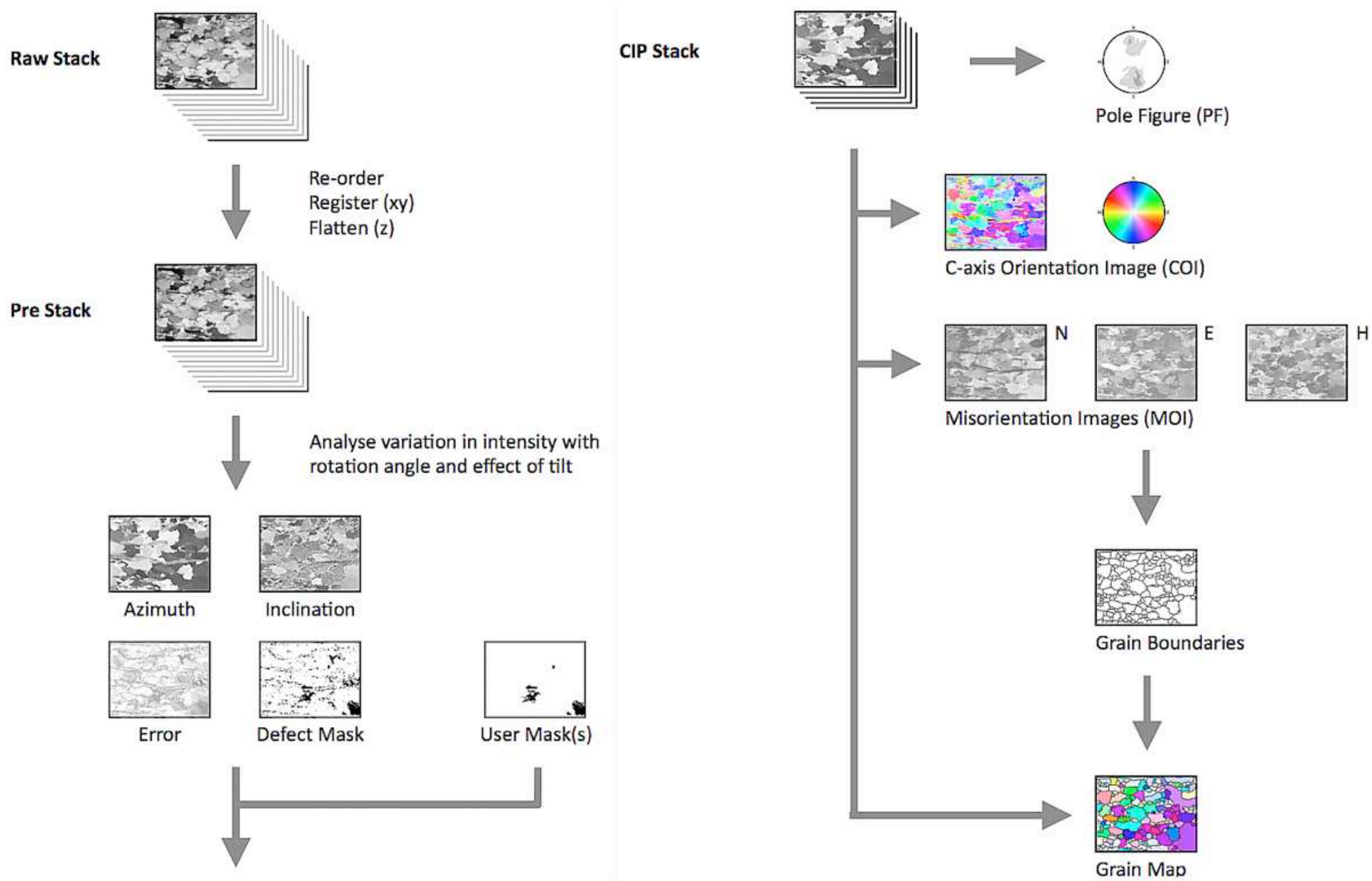
CIP2 and CIP4 yield c-axis orientation images, COI, misorientation images, MOI, orientation gradient images, OGI, and pole figure matrices, POLFIG, that can be converted to pole figures using Image SXM with the Lazy pole macro.

Additional processing of CIP2 and CIP4 results with Image SXM is indicated.

Green = CIP software; yellow = Image SXM; light gray = image files. (Fortran software available from <http://earth.unibas.ch/micro/software>, Image SXM available from <http://www.liv.ac.uk/~sdb/ImageSXM/>).



# PrinCIPia (Image SXM)



## Software Box 22.2

Flow chart for PrinCIPia.

(see <http://www.ImageSXM.org.uk/PrinCIPia>).

Raw Stack = input; Pre Stack = pre-processed input; CIP Stack = output.

import raw image [I]  
insert slice at start [O]

make ROI there [X]

crop and scale - NN [1]  
crop and scale - bilinear [2]  
crop and scale - bicubic [3]

flip stack horizontal [4]  
flip stack vertical [5]  
rotate entire stack 180° [6]

revert ROTs in stack  
rotate stack to reference [R]  
re-center rotation 0-180 [K]

import Text LUT  
apply camera LUT [Y]  
invert stack

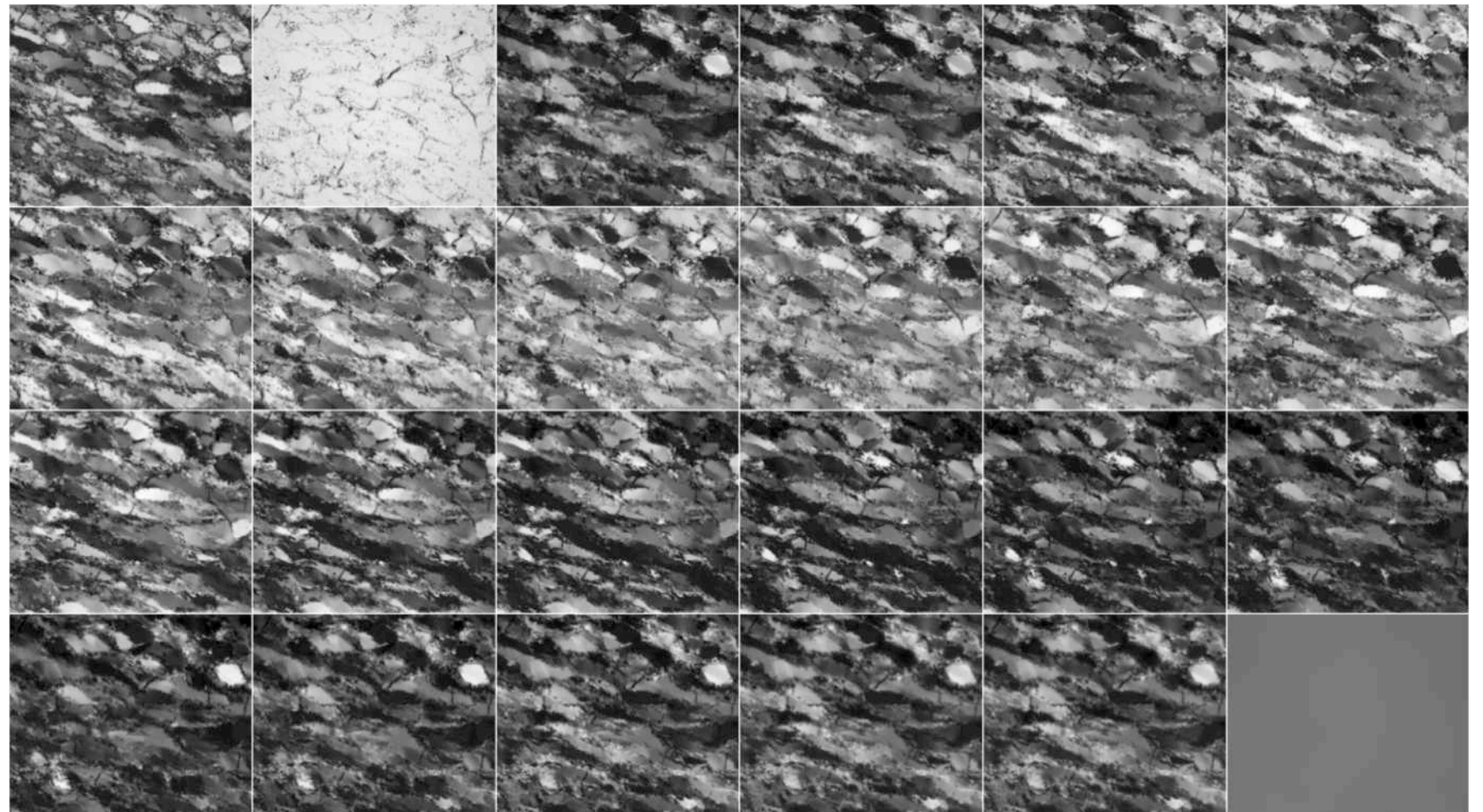
flare-correct rotated images [F]  
REAL flat field [S]  
REAL subtract background [Z]  
rolling ball [B]

merge tilts [T]  
check averages of tilts [M]

smooth stack from to ... [C]  
average stack [A]  
Grayscale [G]  
invert image [J]  
scale to pixel [P]

export stack to RAW - 19 rot [E]

## Lazy prepstack

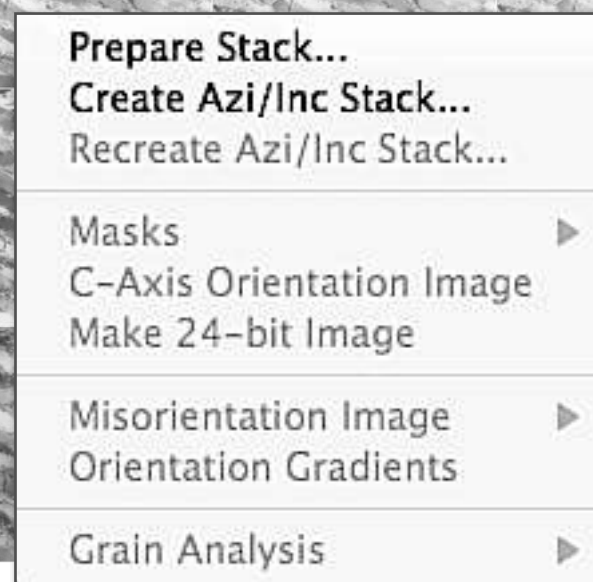
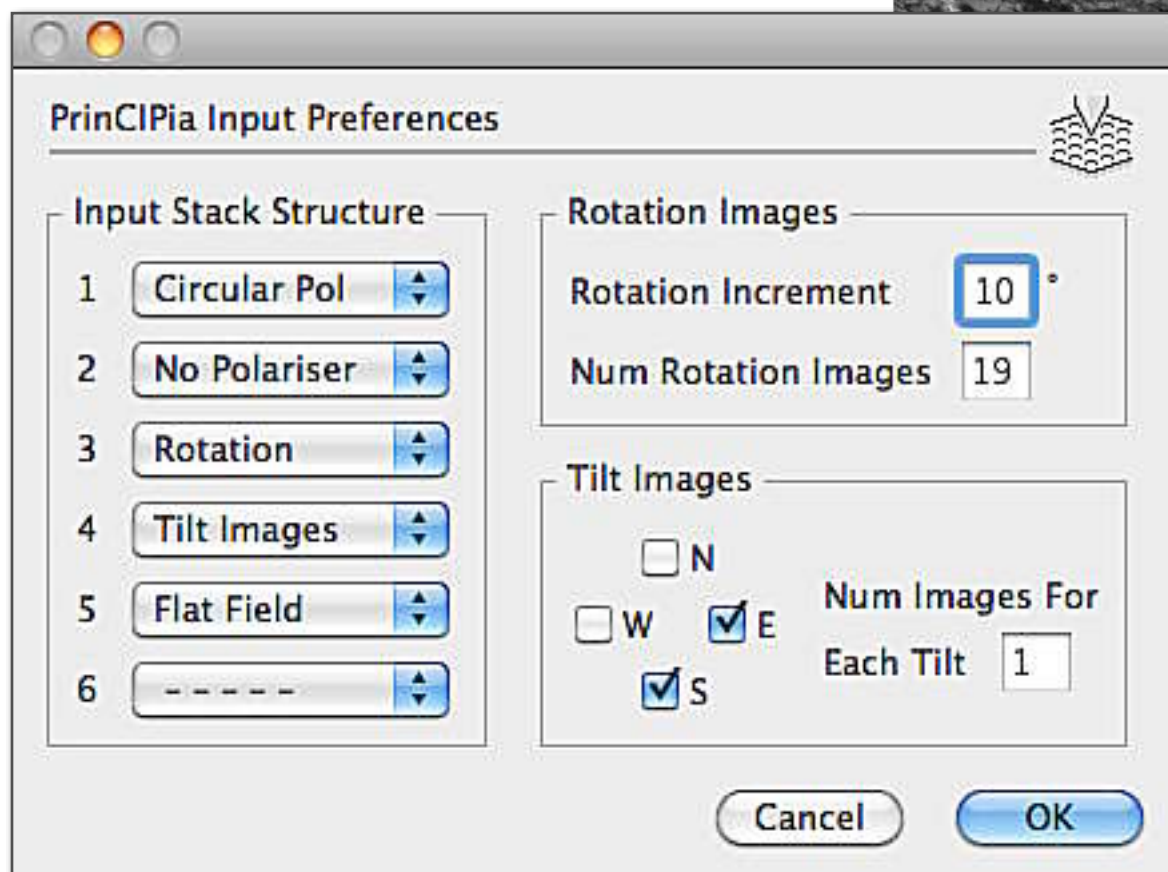
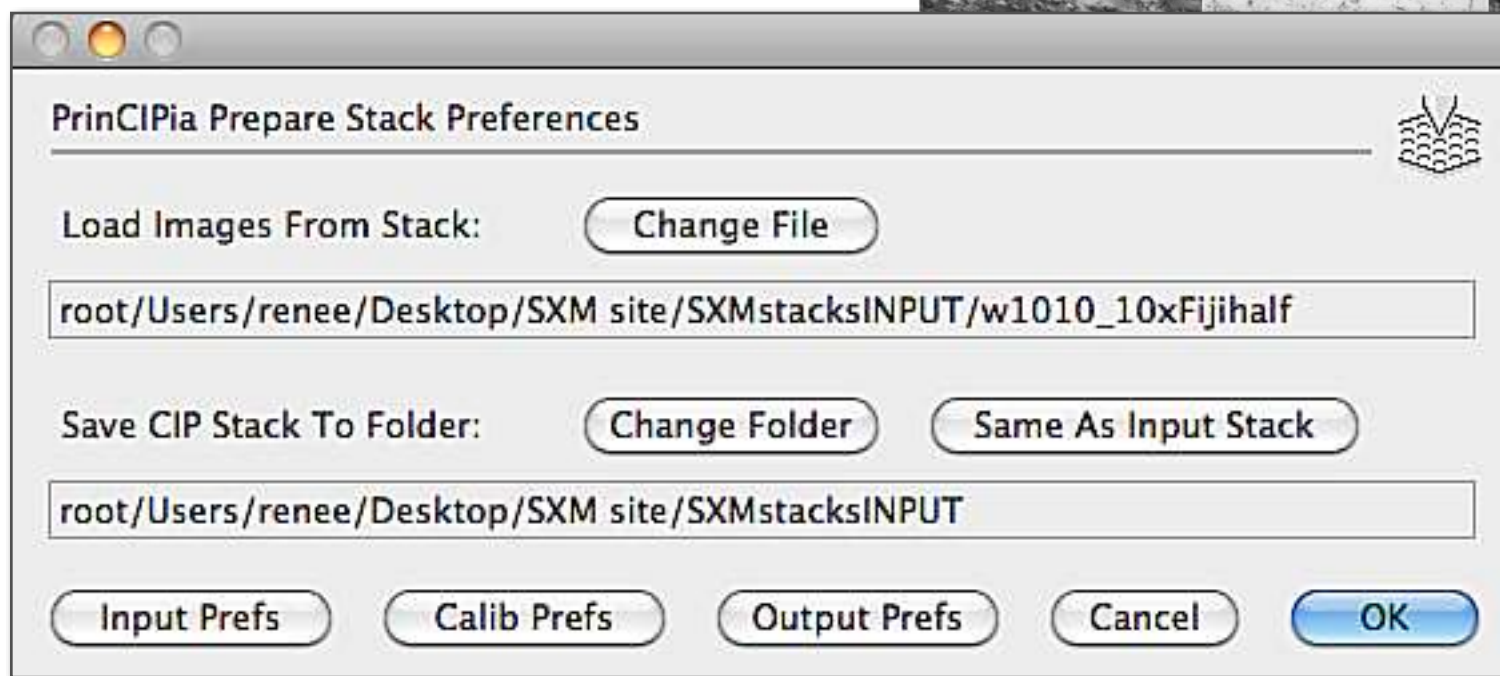


### Software Box 22.3

Input for CIP software.

Left: Lazy prepstack is a macro for Image SXM (available from <http://earth.unibas.ch/micro/software>);  
right: montage of 24 input images (raw images).





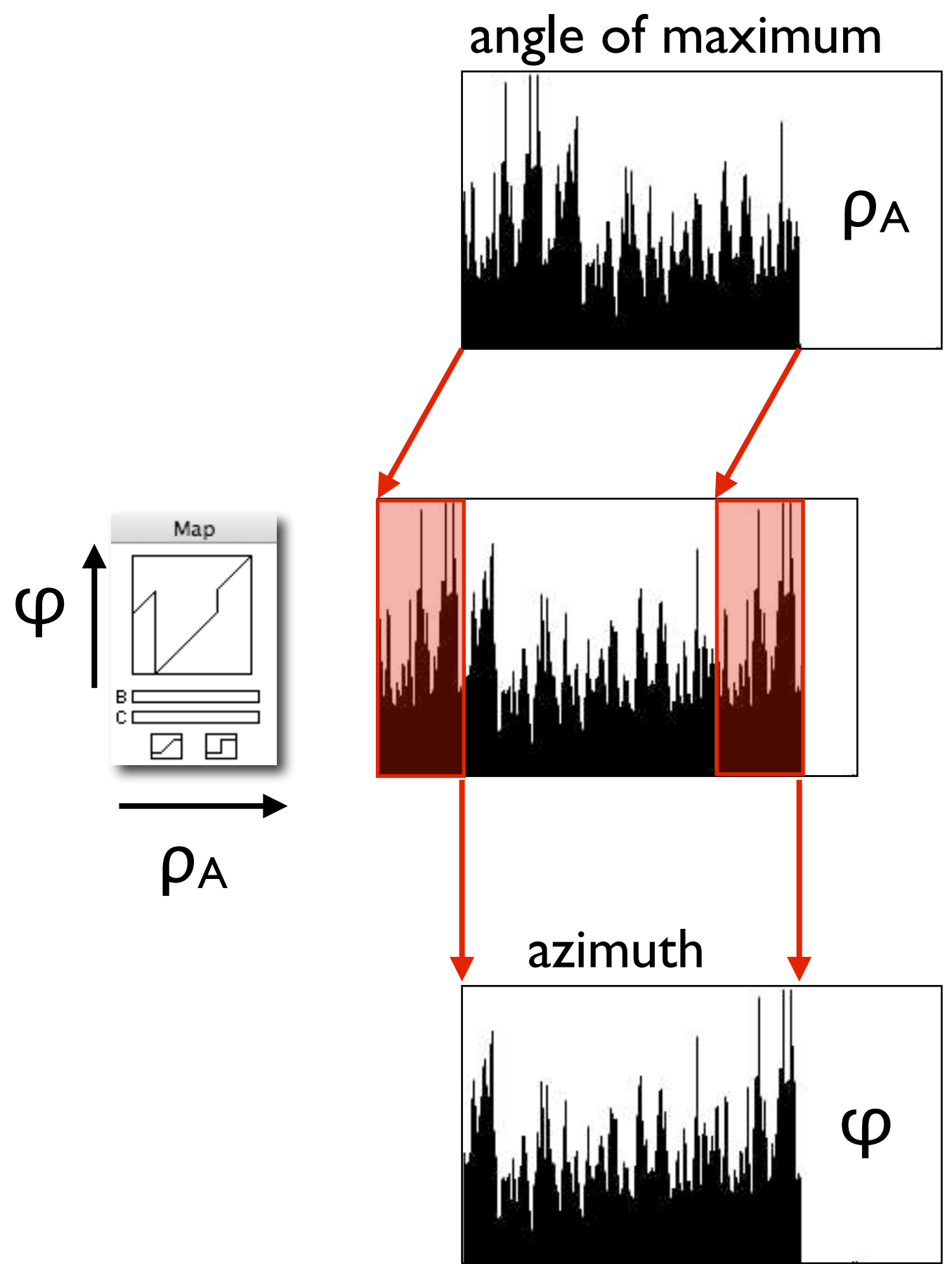
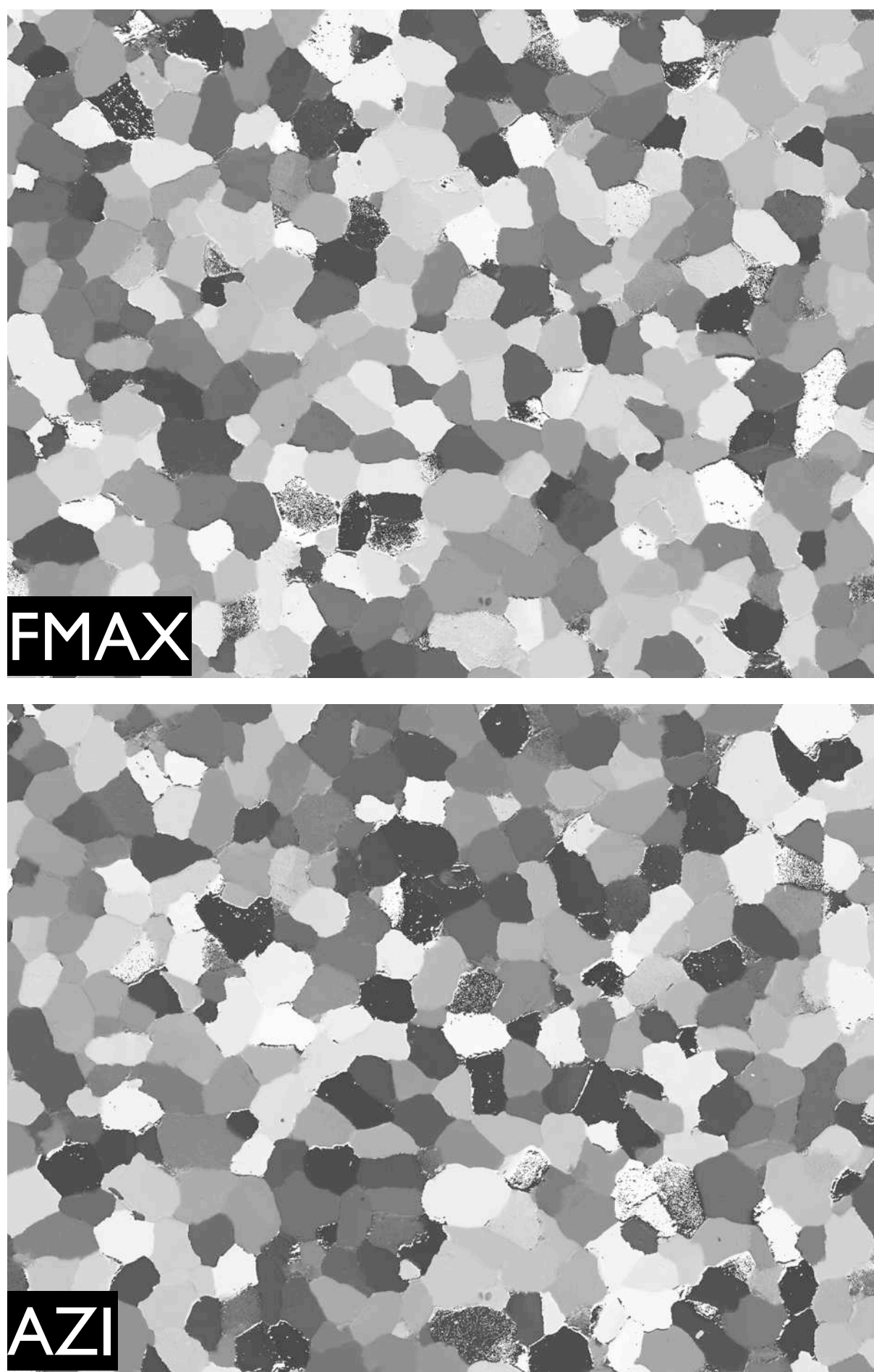
## Software Box 22.4

Input for CIP software prepared by PrinCIPia.

Top right: montage showing input stack (Raw Stack); bottom right: montage showing ordered, registered and flattened stack (Pre Stack).

Left: Dialog windows for PrinCIPia.





**Figure 22.26**

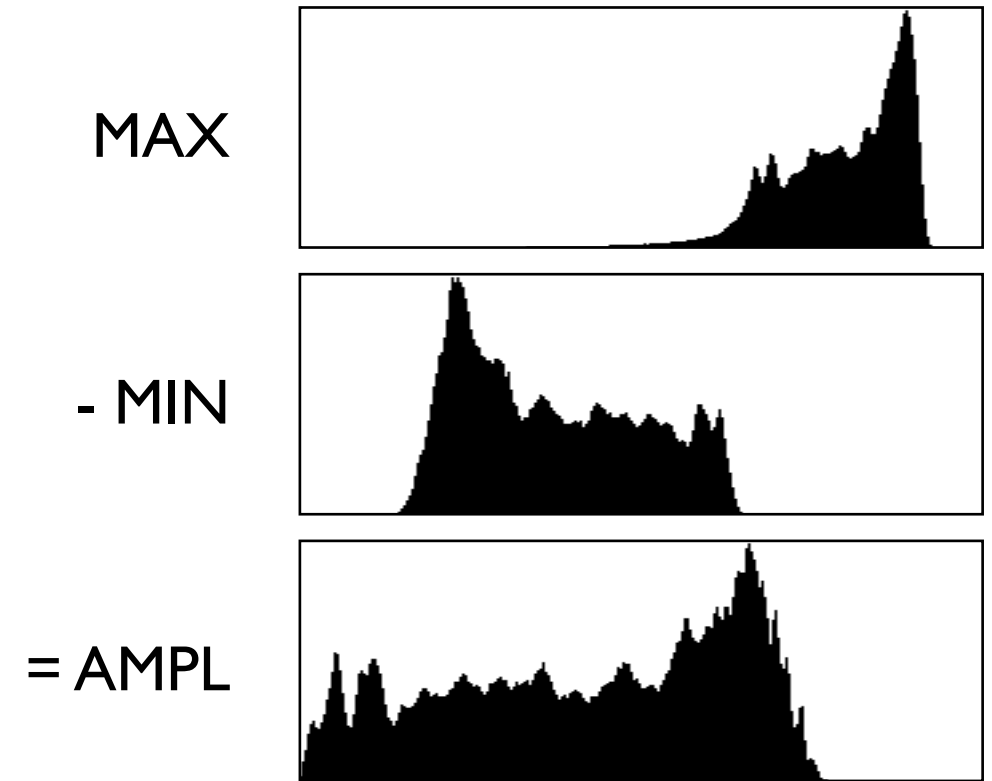
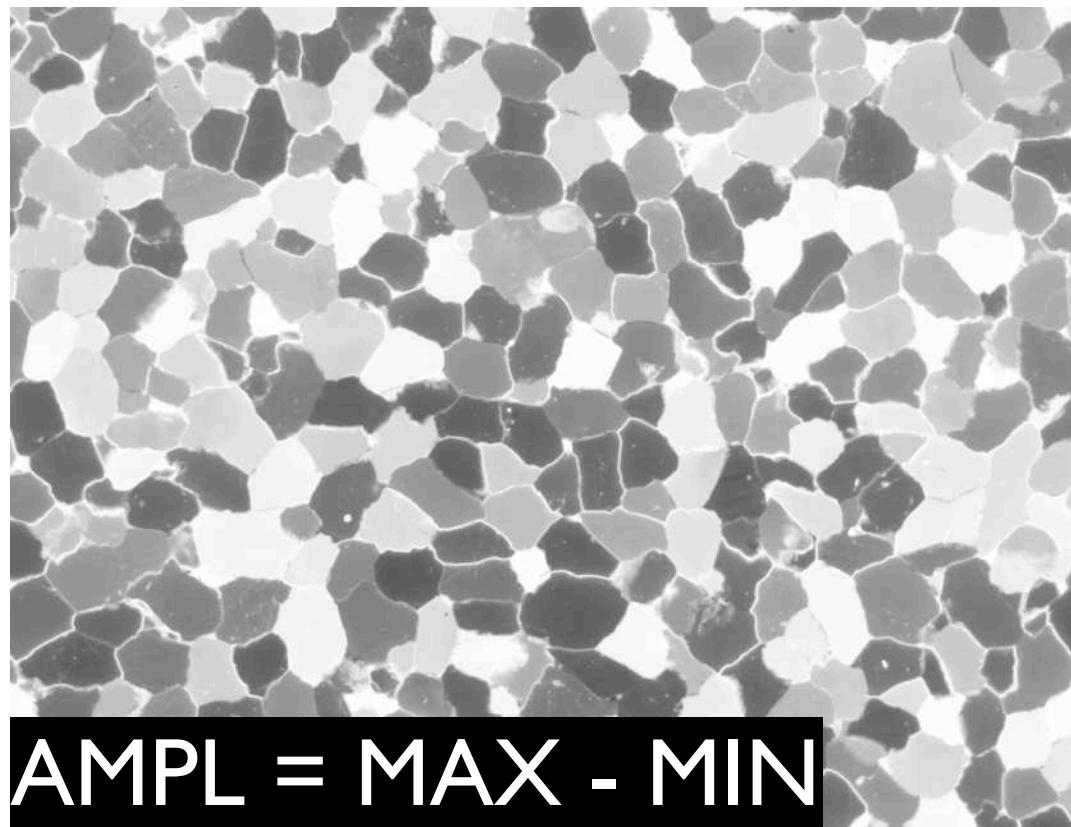
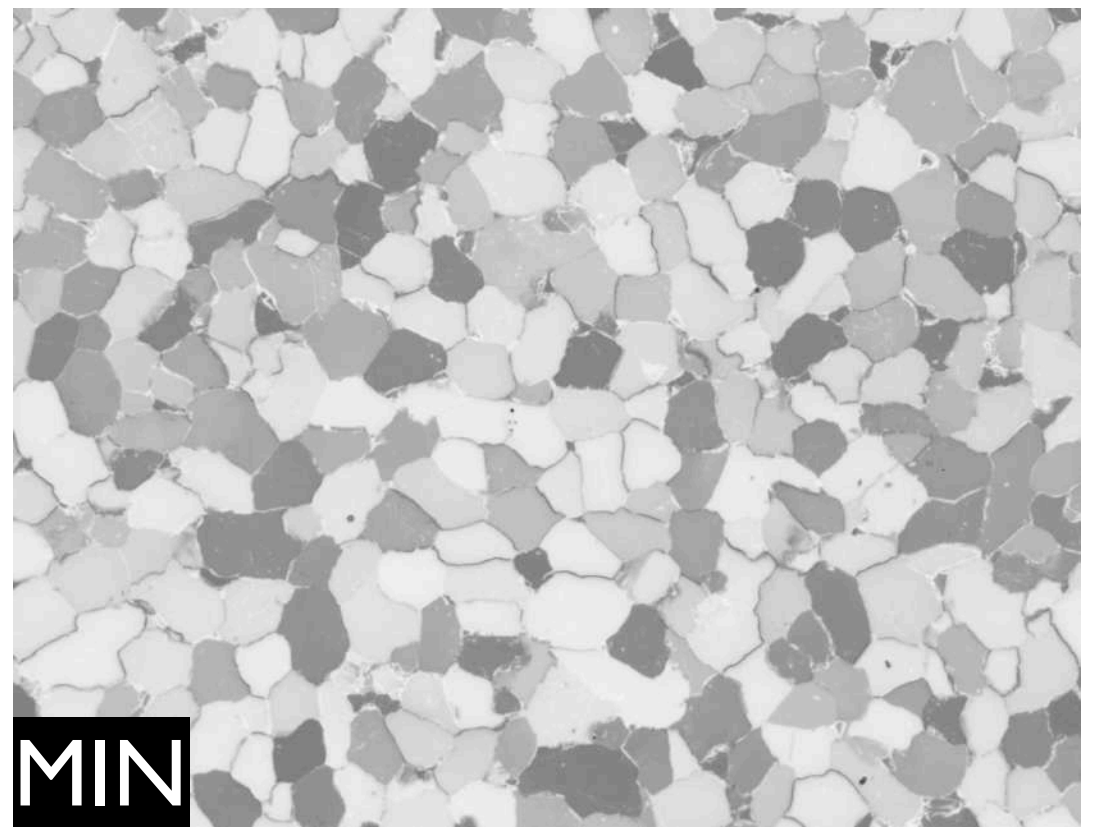
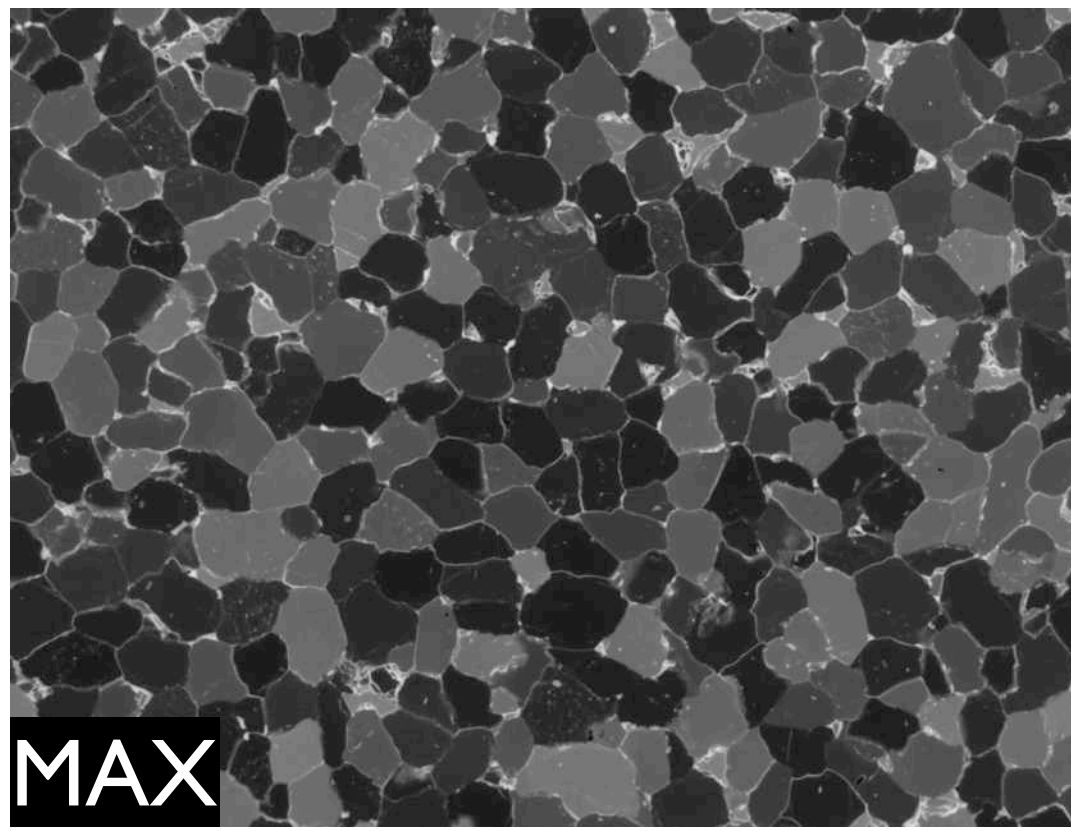
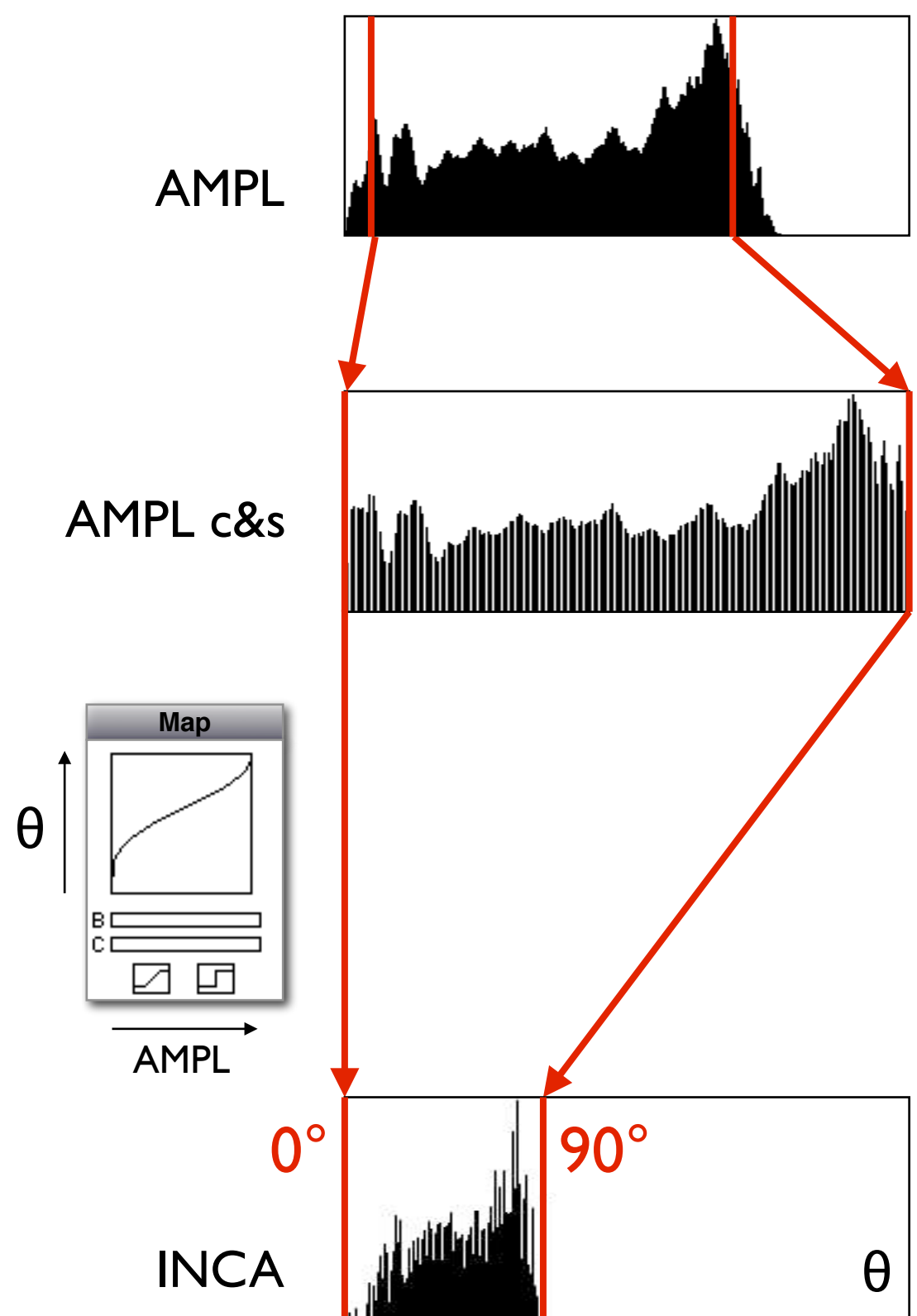
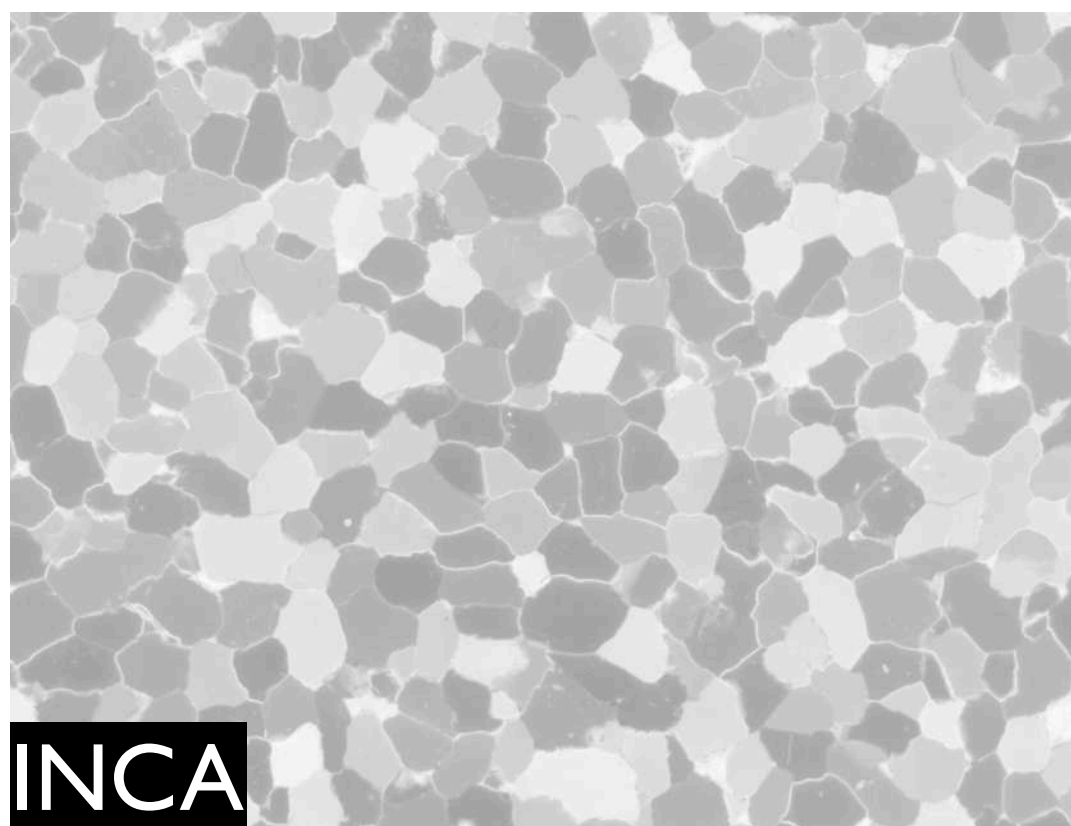
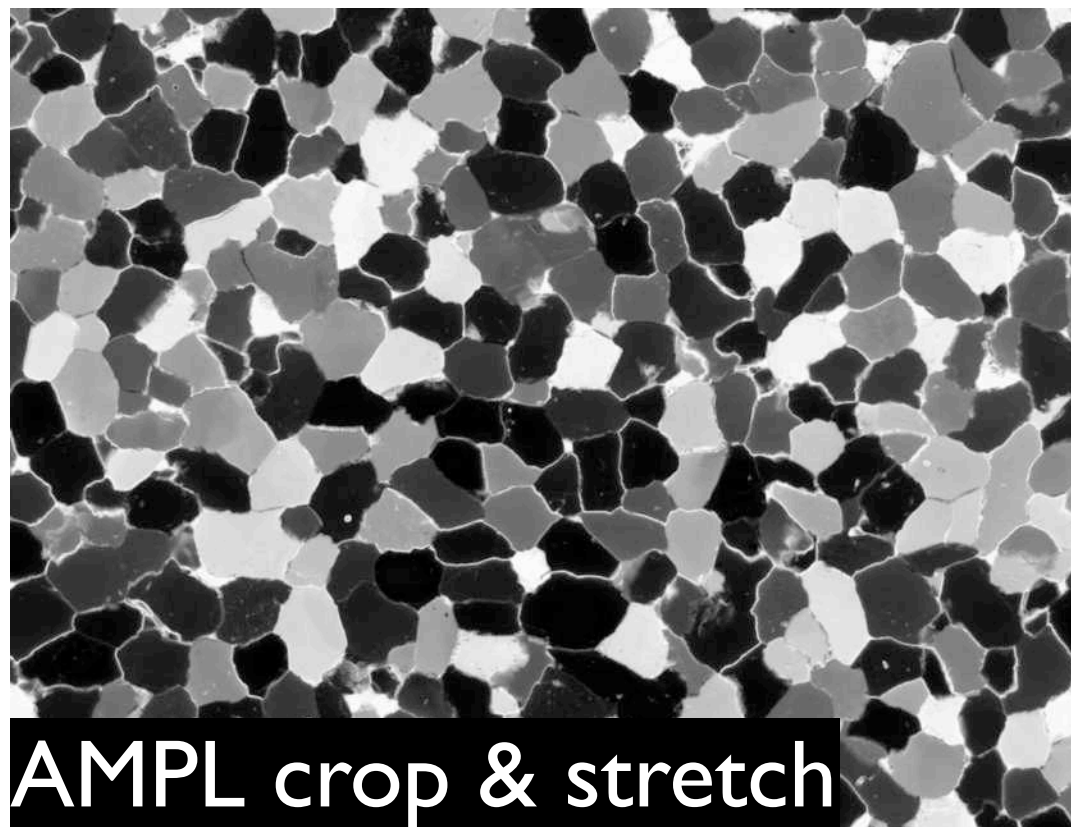
Azimuth from rotations.

From the phase angle,  $\rho_A$ , the azimuth,  $\varphi$ , is derived by inverting the relation,  $\rho_A(\varphi)$ , shown in Figure 22.4.

FMAX = image of phase angle,  $\rho_A$ ; AZI = image of derived azimuth,  $\varphi$ ;

Map shows the look-up table (LUT); on the right: histograms show the effect of the LUT.



**a****b****Figure 22.27**

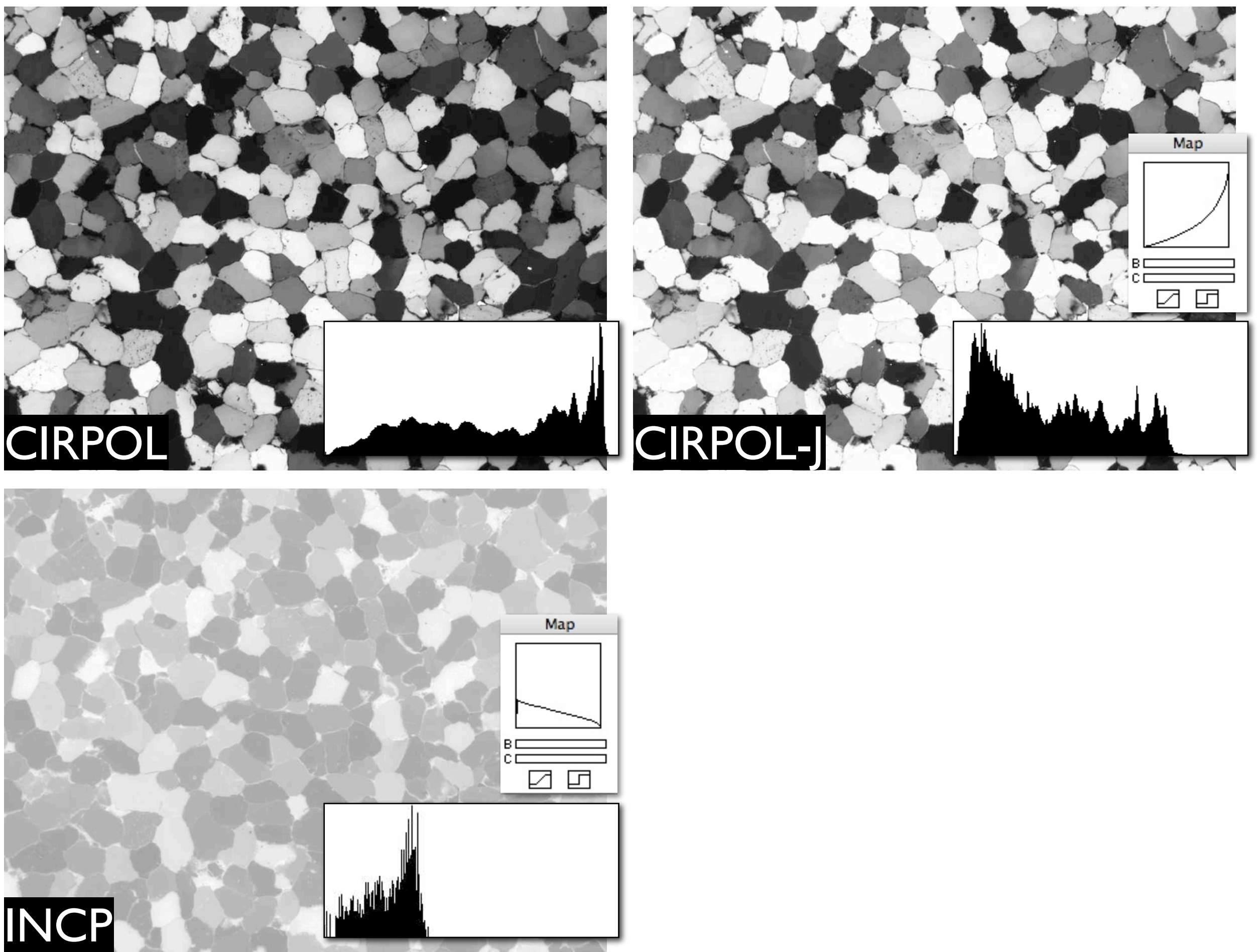
Primary inclinations from amplitude.

(a) From the amplitude,  $A$ , of the rotation signal the inclination,  $\theta$ , is derived by inverting the relation,  $A(\theta)$ , shown in Figure 22.4;

MAX = image of maximum intensity (gray value encoding renders maximum as black); MIN = image of minimum intensity, AMPL = image of difference (MAX-MIN);

(b) the amplitude is converted to inclination using the  $\theta(A)$  LUT; AMPL c&s = image with cropped and stretched gray values (0-255); INCA = image of primary inclinations ( $0^\circ$ - $90^\circ$ ) derived from amplitude of rotation signal.





**Figure 22.28**

Primary inclination from circular polarization.

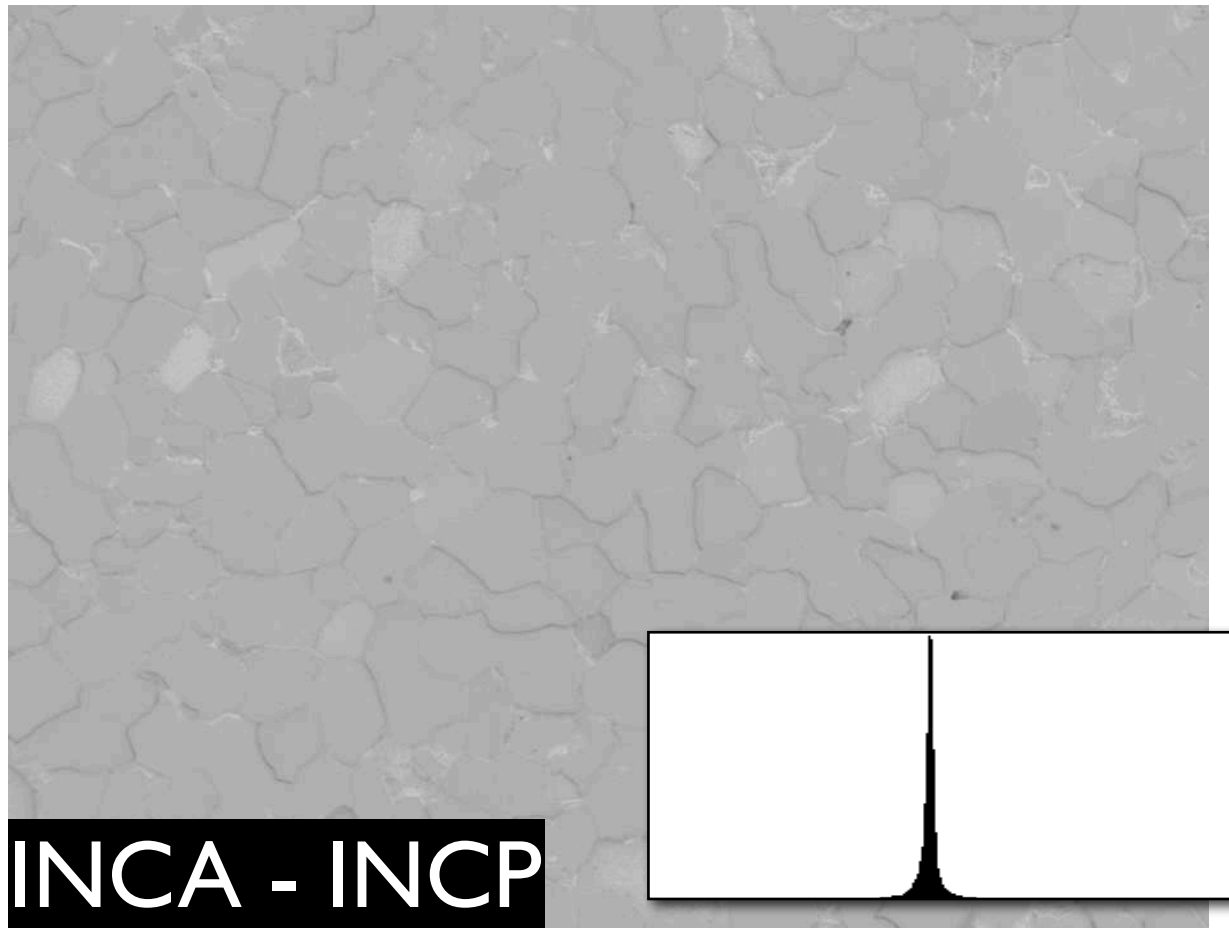
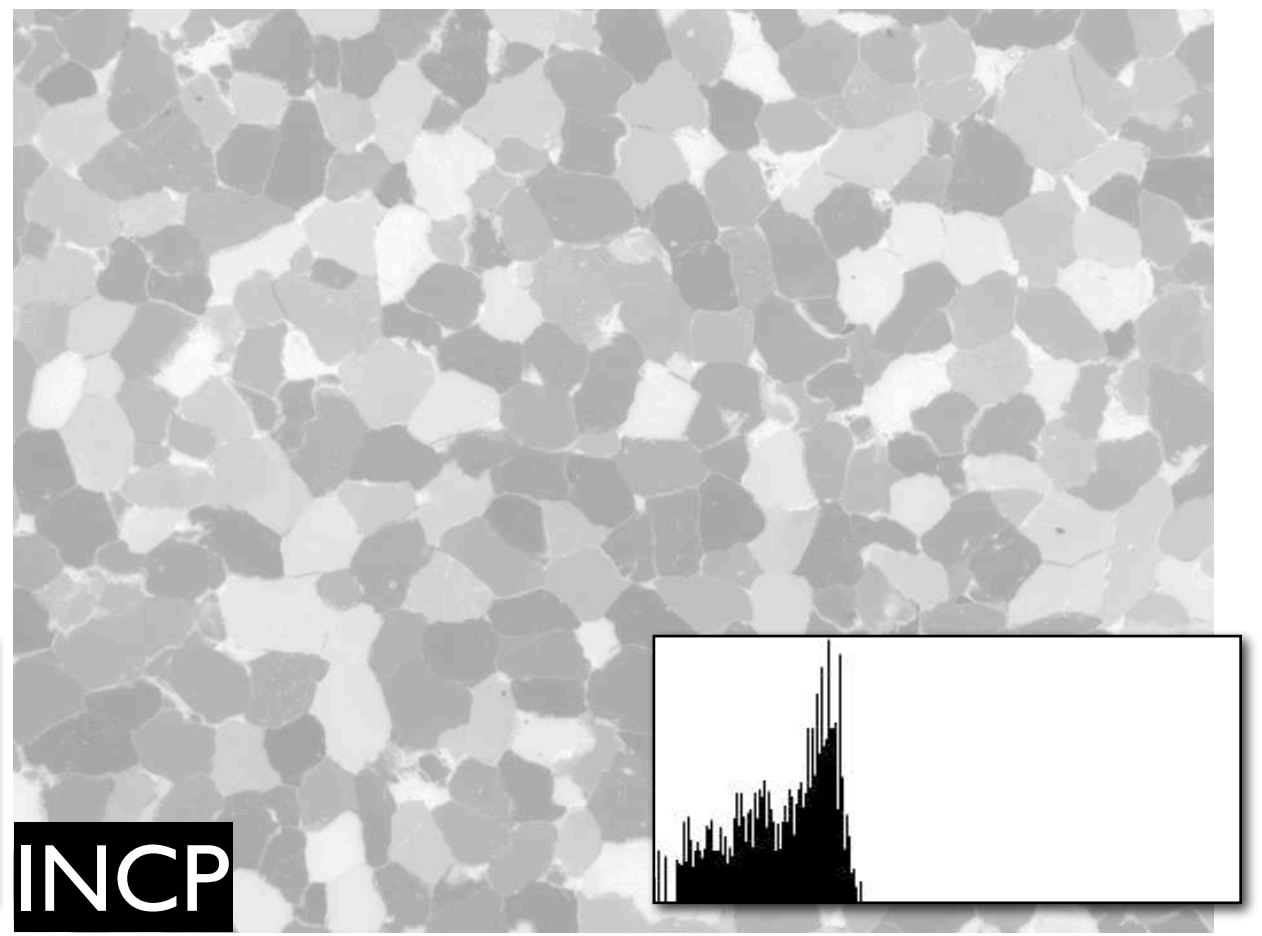
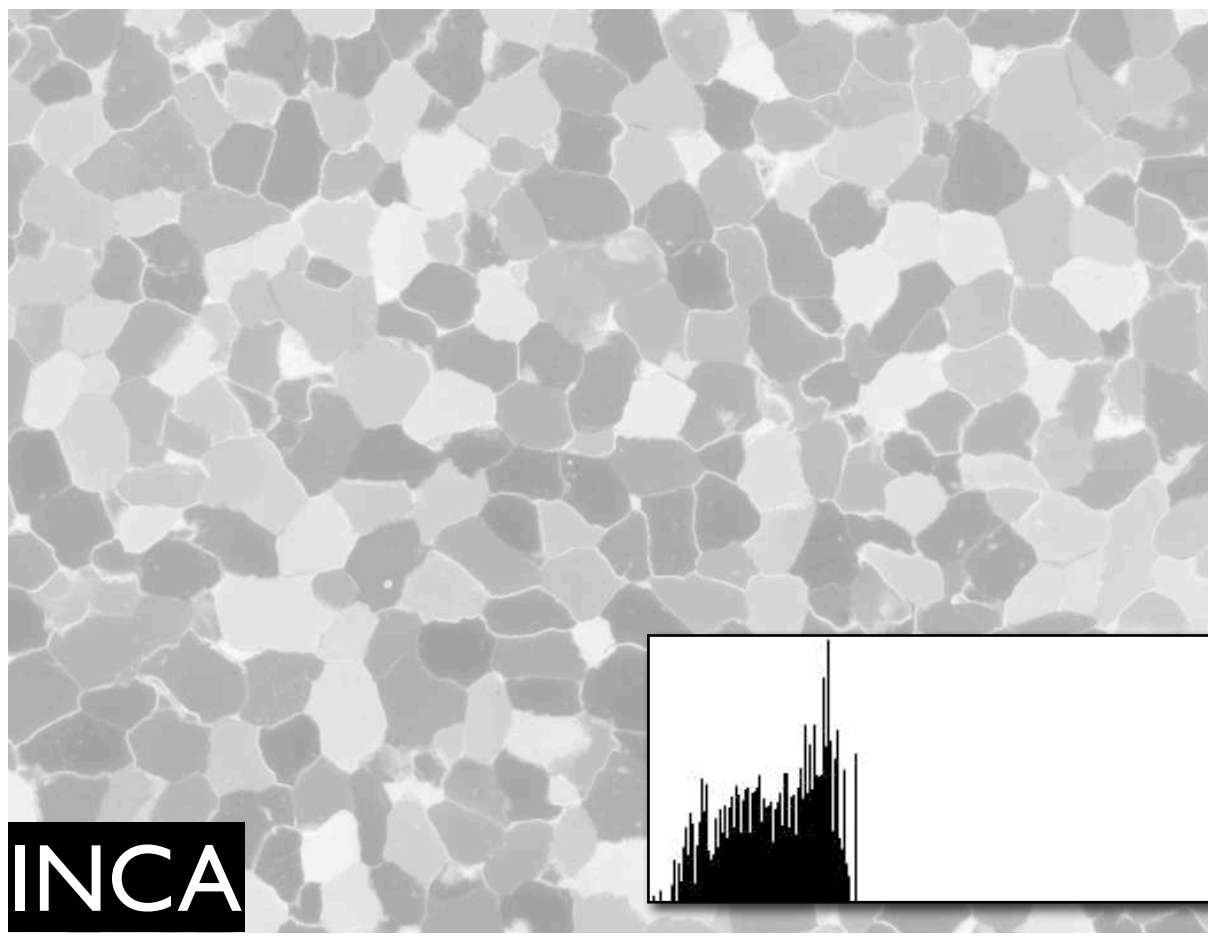
From the intensity of the circular polarization image,  $J$ , the inclination,  $\theta$ , is derived by inverting the relation,  $J(\theta)$ , shown in Figure 22.4.

CIRPOL = circular polarization image; CIRPOL-J = (linear) intensities of CIRPOL image; INCP = image of primary inclinations derived from circular polarization.

Map on CIRPOL-J shows the look-up table (LUT) (camera calibration) that converts CIRPOL to CIRPOL-J; Map on INCP converts CIRPOL-J to INCP in the range of  $(0^\circ < \theta < 90^\circ)$ .

Note that intensities of CIRPOL-J are shown with brightness encoding: high intensities have low gray values and appear white.



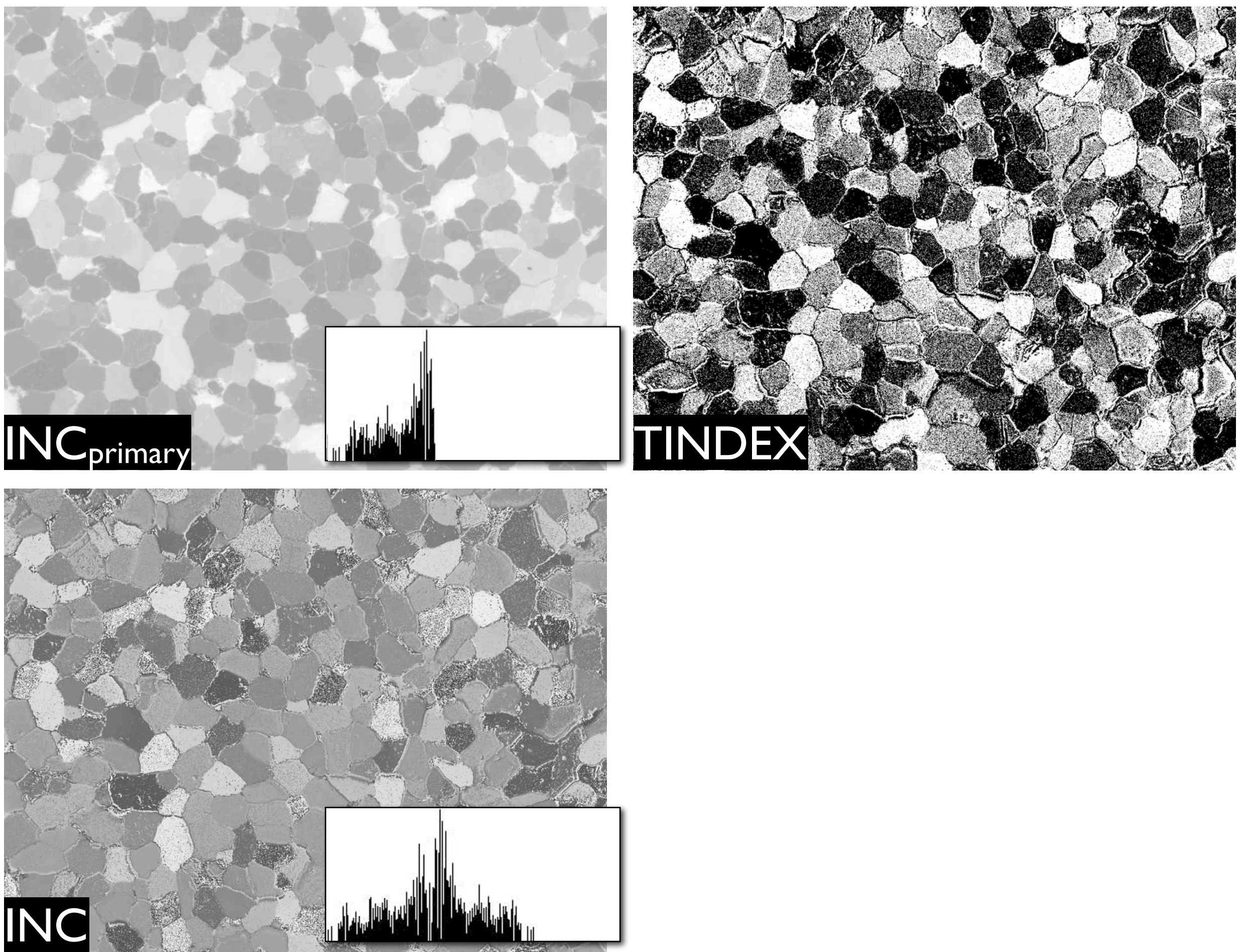


**Figure 22.29**

Comparison of primary inclination images.

INCA = image of primary inclinations derived from amplitude of rotation signal; INCP = image of primary inclinations derived from circular polarization; difference image is obtained by subtracting INCP from INCA and adding 127 (average gray in image); histogram shows that INCA and INCP are essentially identical.





**Figure 22.30**

Tilt correction

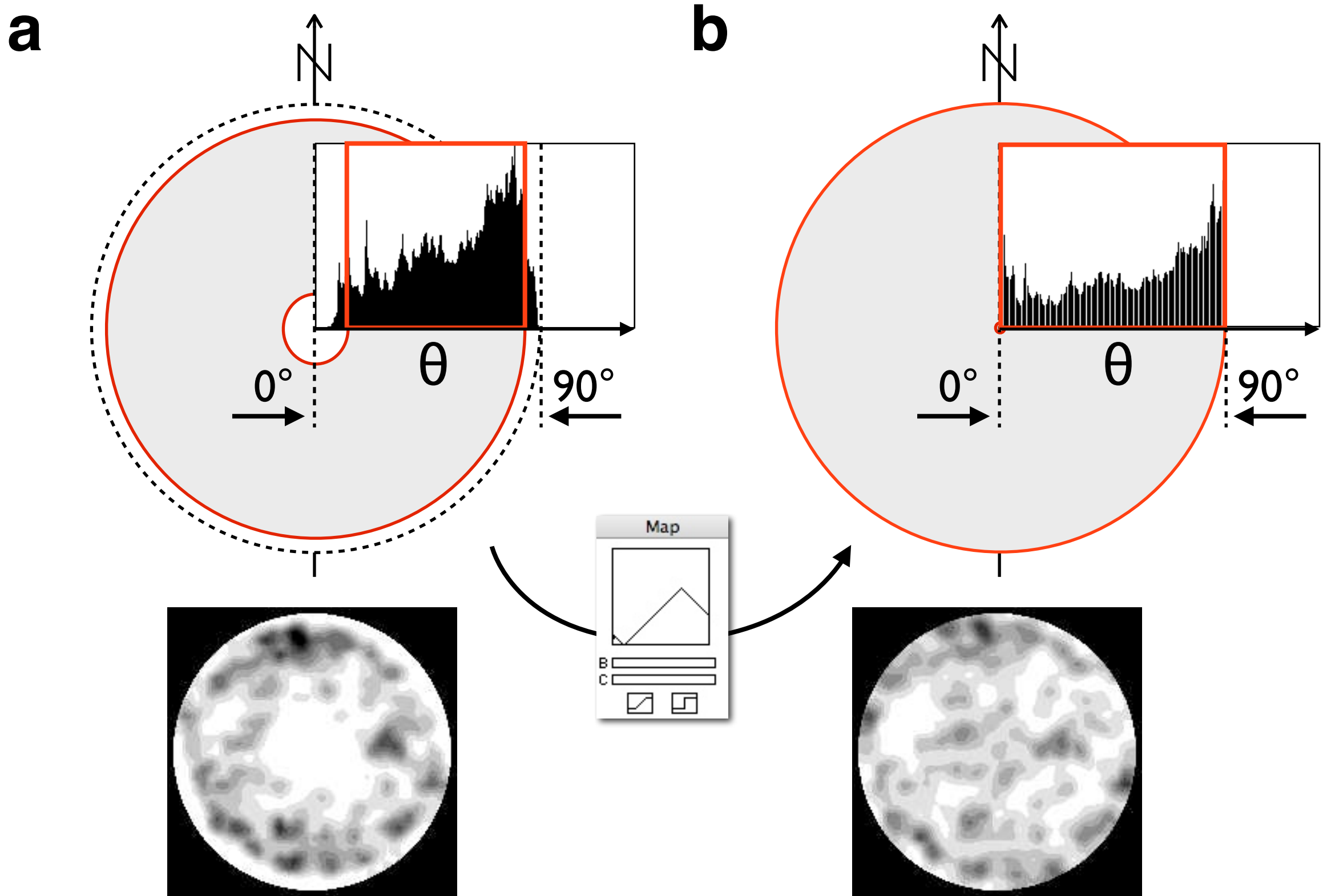
To convert the primary inclination files to full inclination the tilt index file is used. The example of

$INC_{\text{primary}}$  = primary inclination file (INCA or INCP in Figure 22.29);

TINDEX (tilt index) = indicator file marking primary inclination for flip to 3rd and 4th quadrant (left side) of orientation half space (situation A or D in Figure 22.5):  $INC = 180^\circ - INC_{\text{primary}}$ .

INC = full inclination image where  $(0^\circ < \theta < 180^\circ)$ .





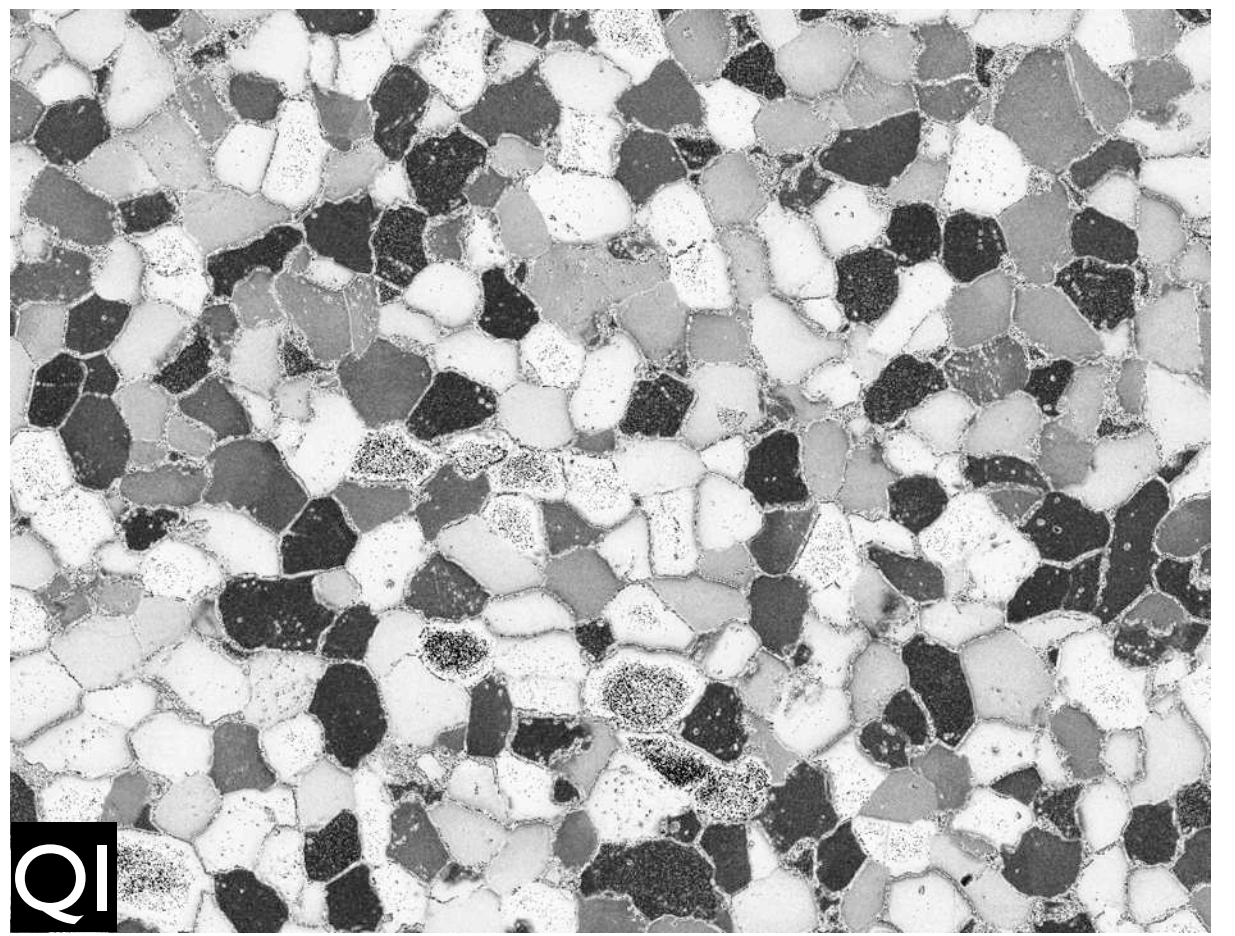
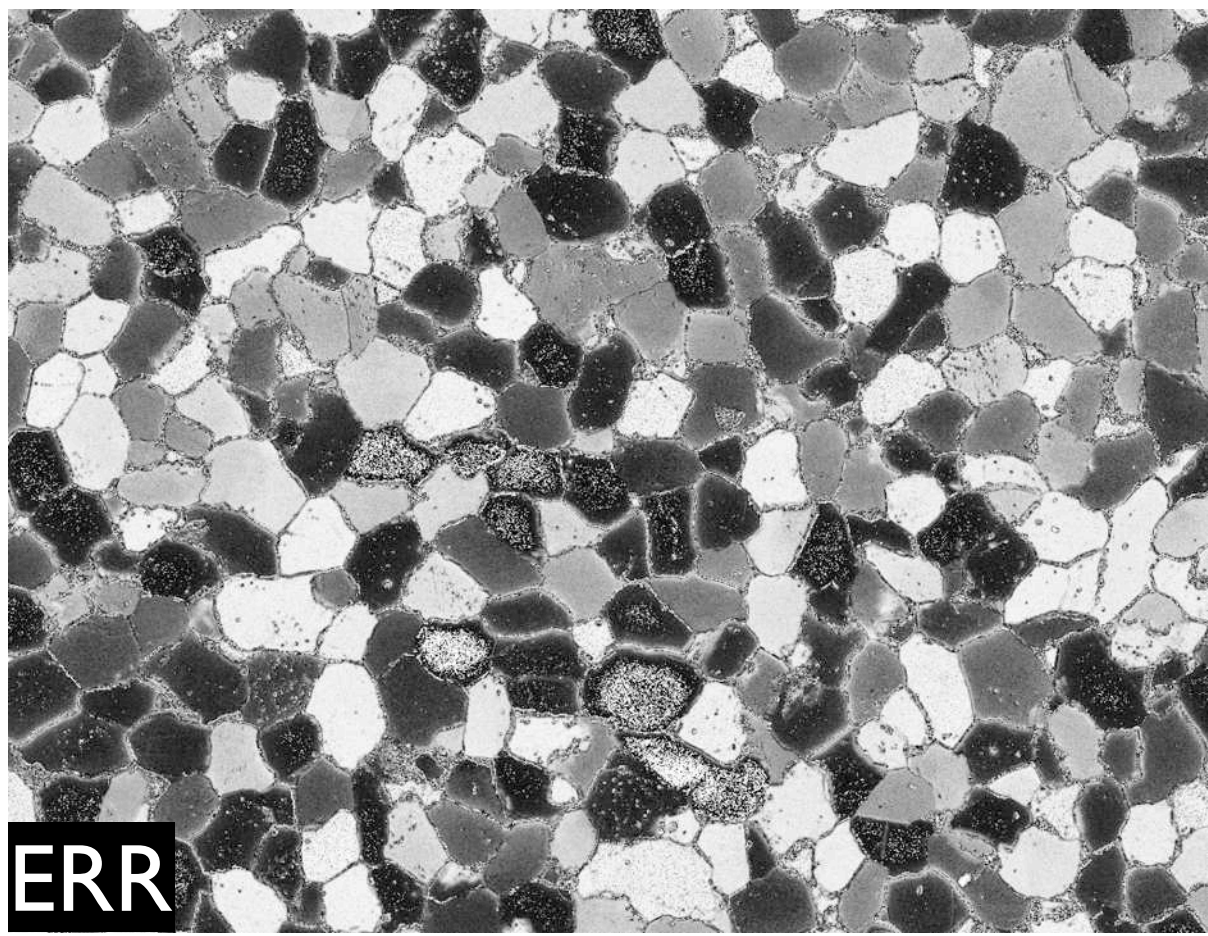
**Figure 22.3 I**

Histogram cropping.

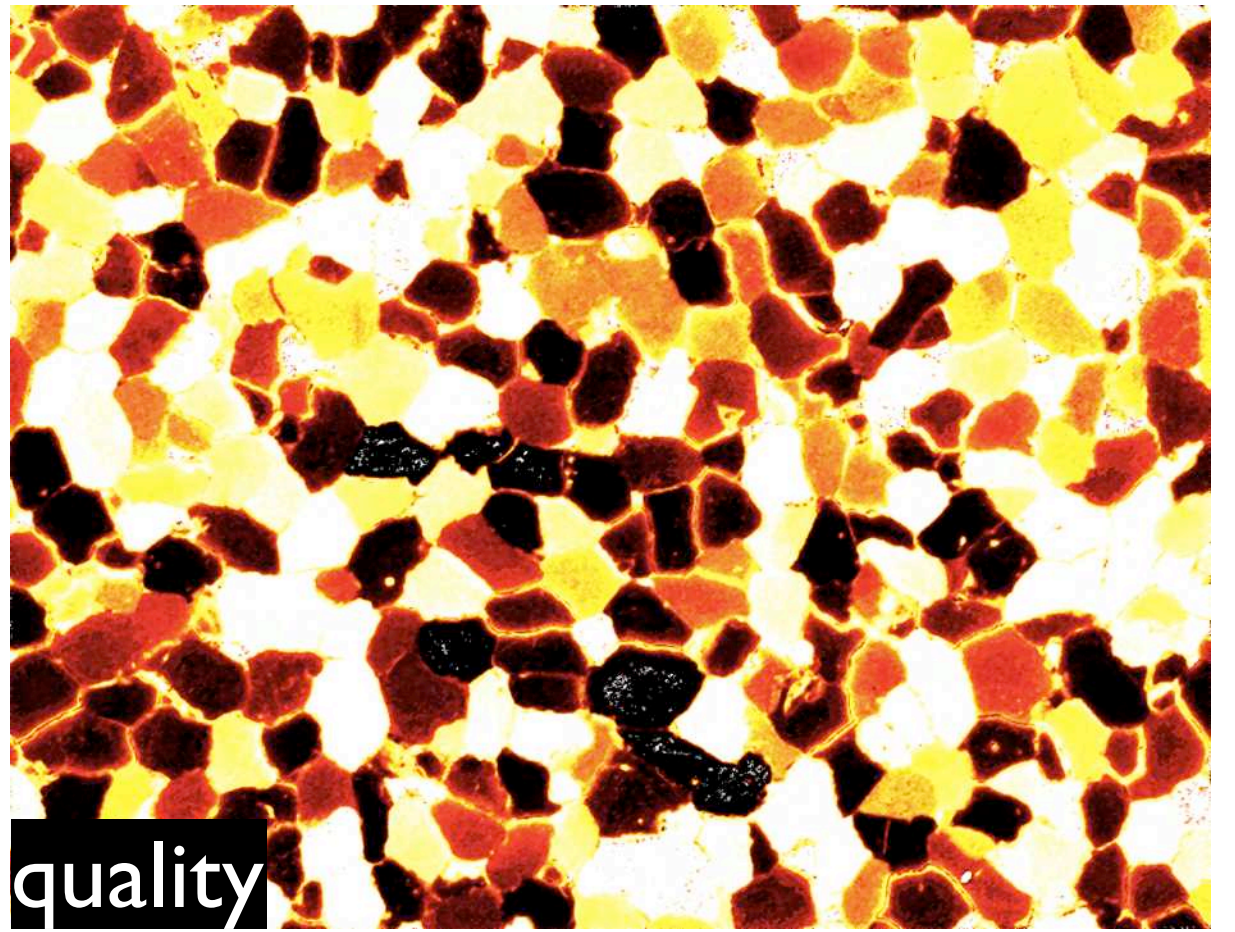
Histograms of CIRPOL-J intensities (Figure 22.28) of a random texture are shown superposed on pole figure coordinates; below: corresponding pole figures.

(a) Using the full range of inclinations, without cropping, causes artifacts in pole figure ('doughnut texture'); (b) using cropped range of values produces correct pole figure; cropping LUT is shown in the middle.





high  
low

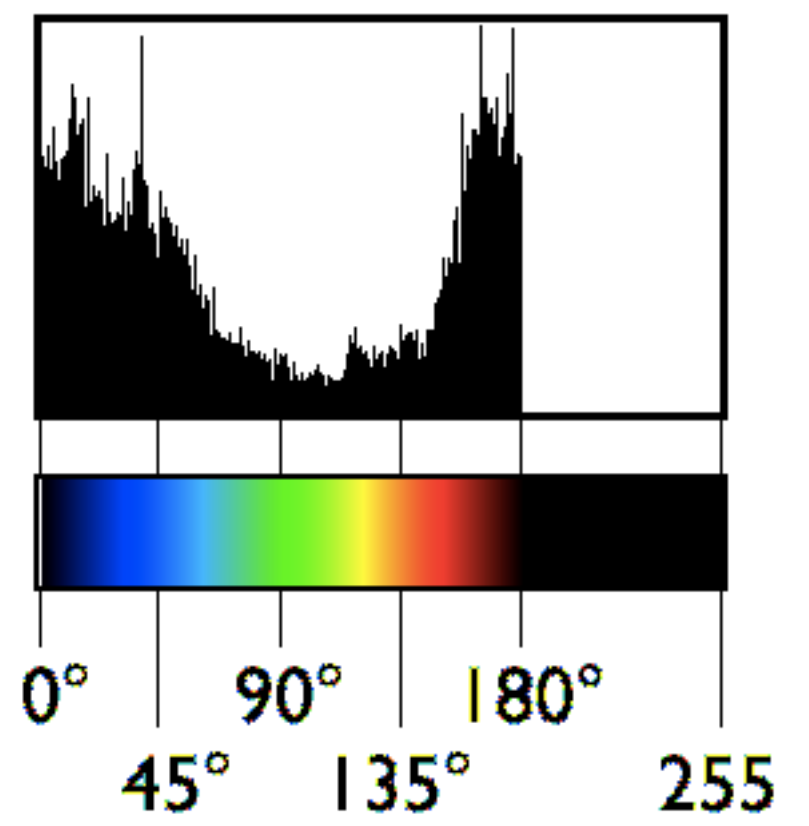
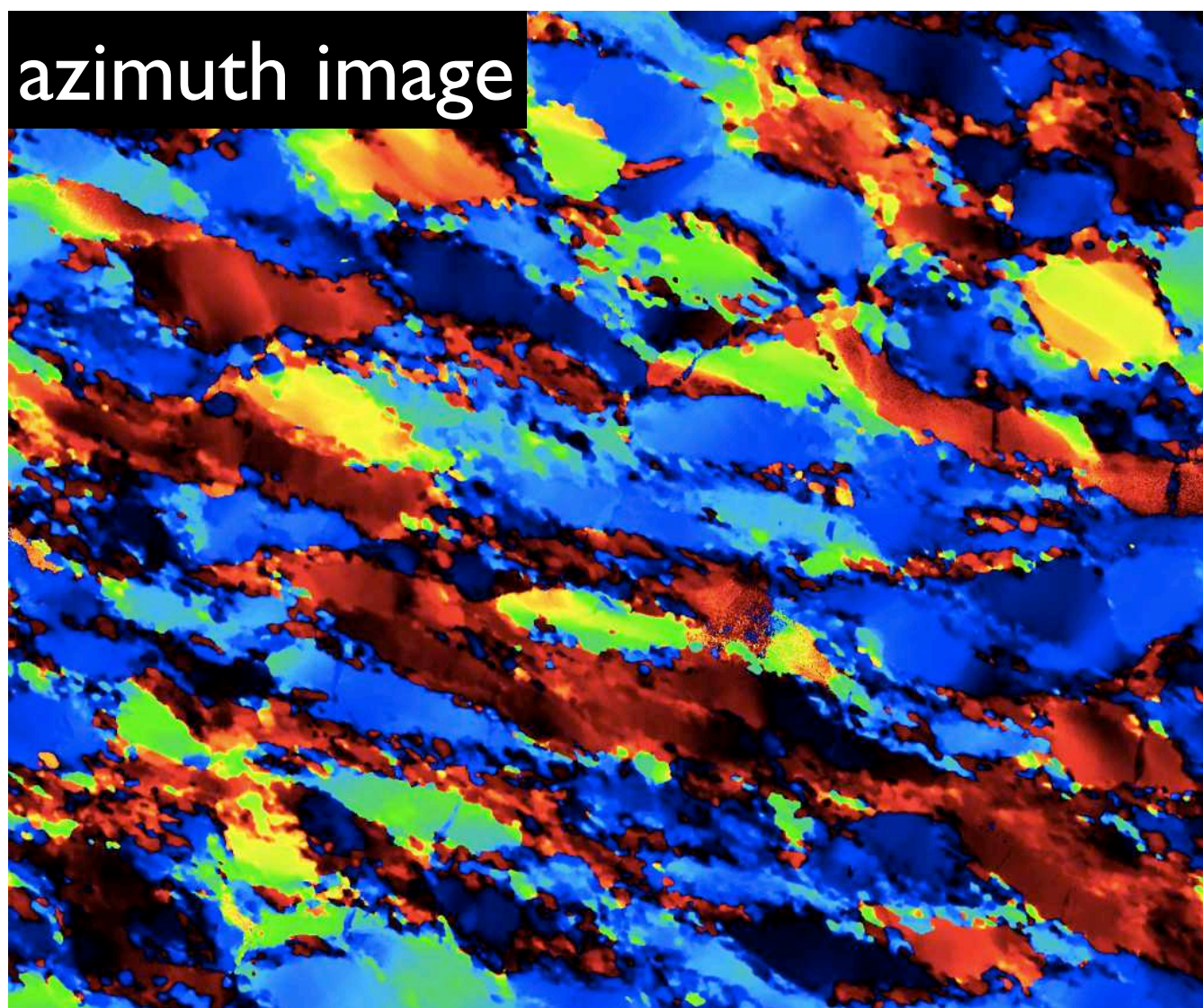
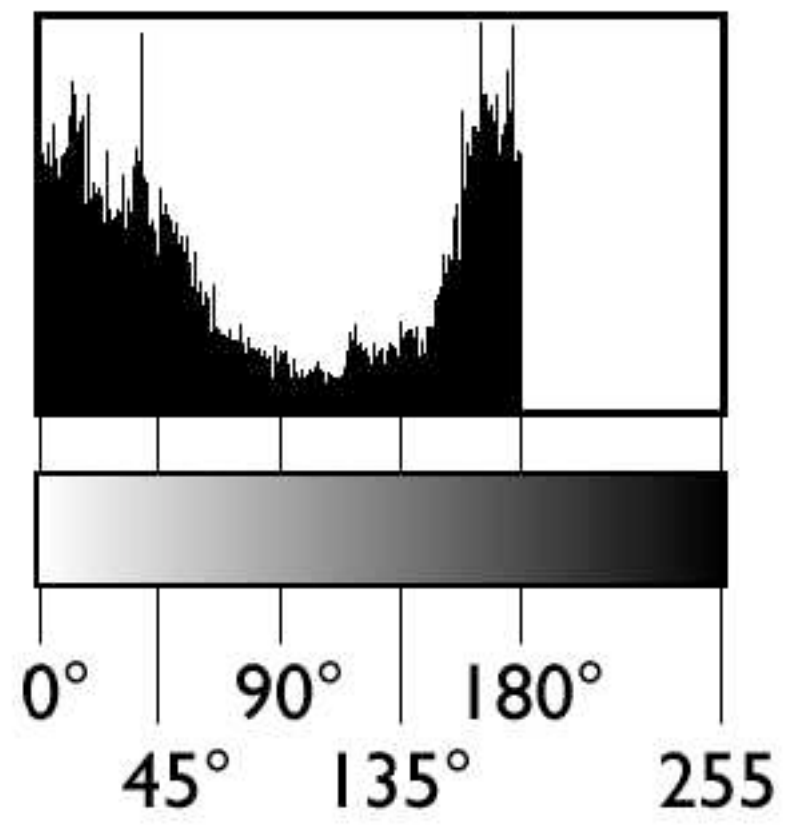
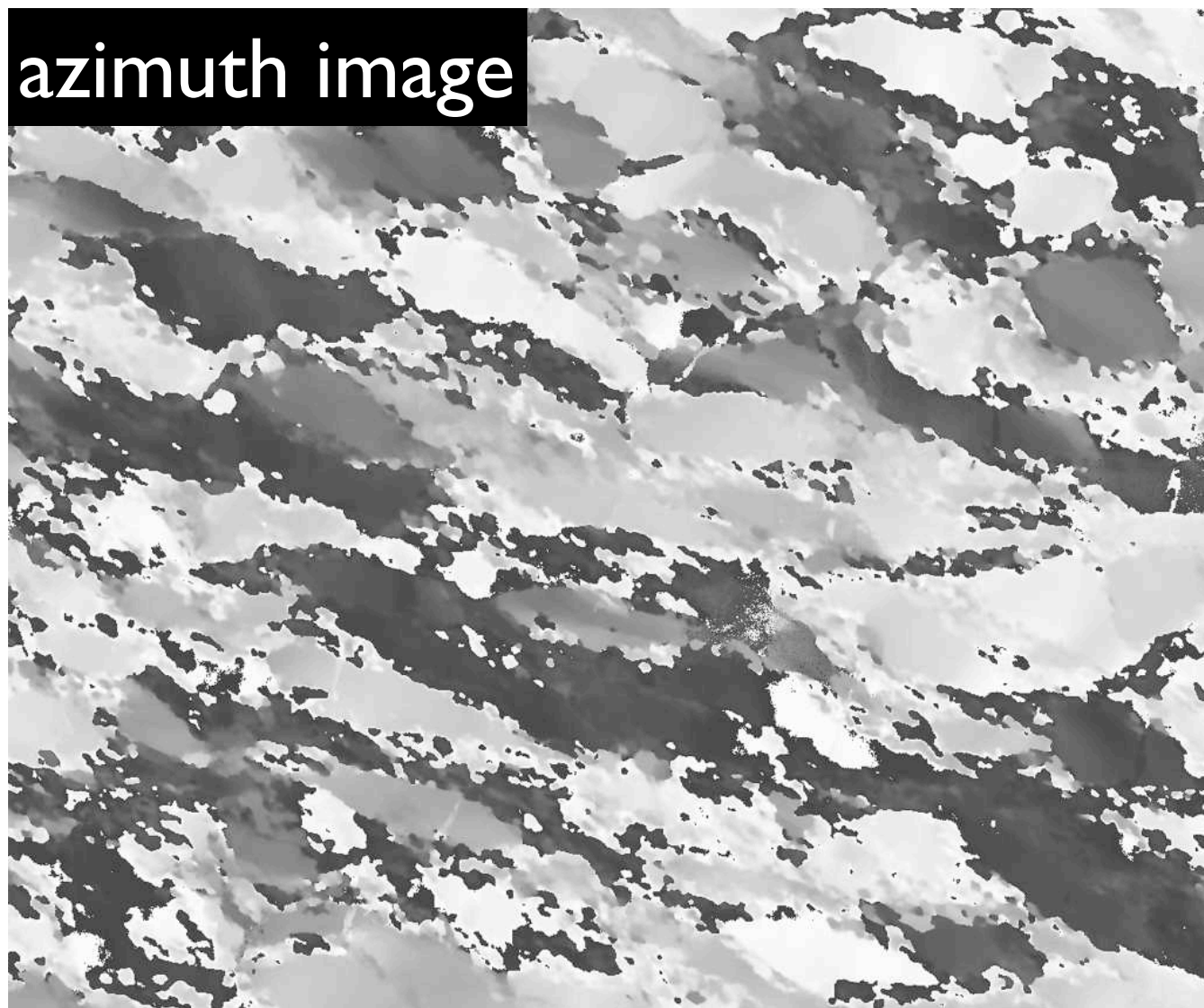


**Figure 22.32**

Error image.

Deviations of the intensity values of the rotation signal,  $J(\rho)$ , from the curve fit are used to calculate the error. The inverse of the error image (ERR) yields a quality index (QI). High values in the error image (black) denote poor quality.





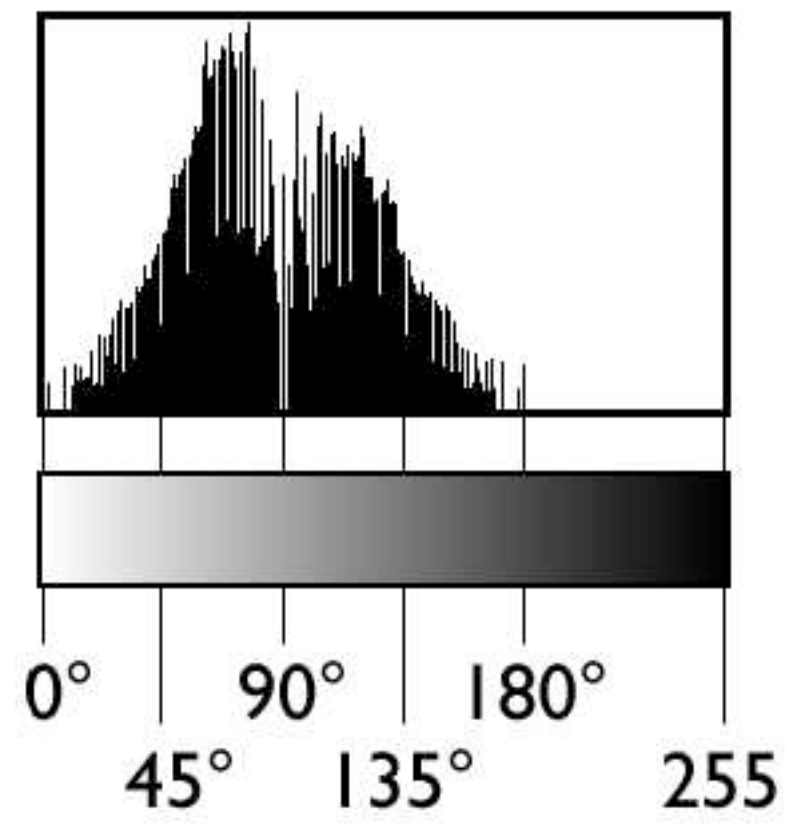
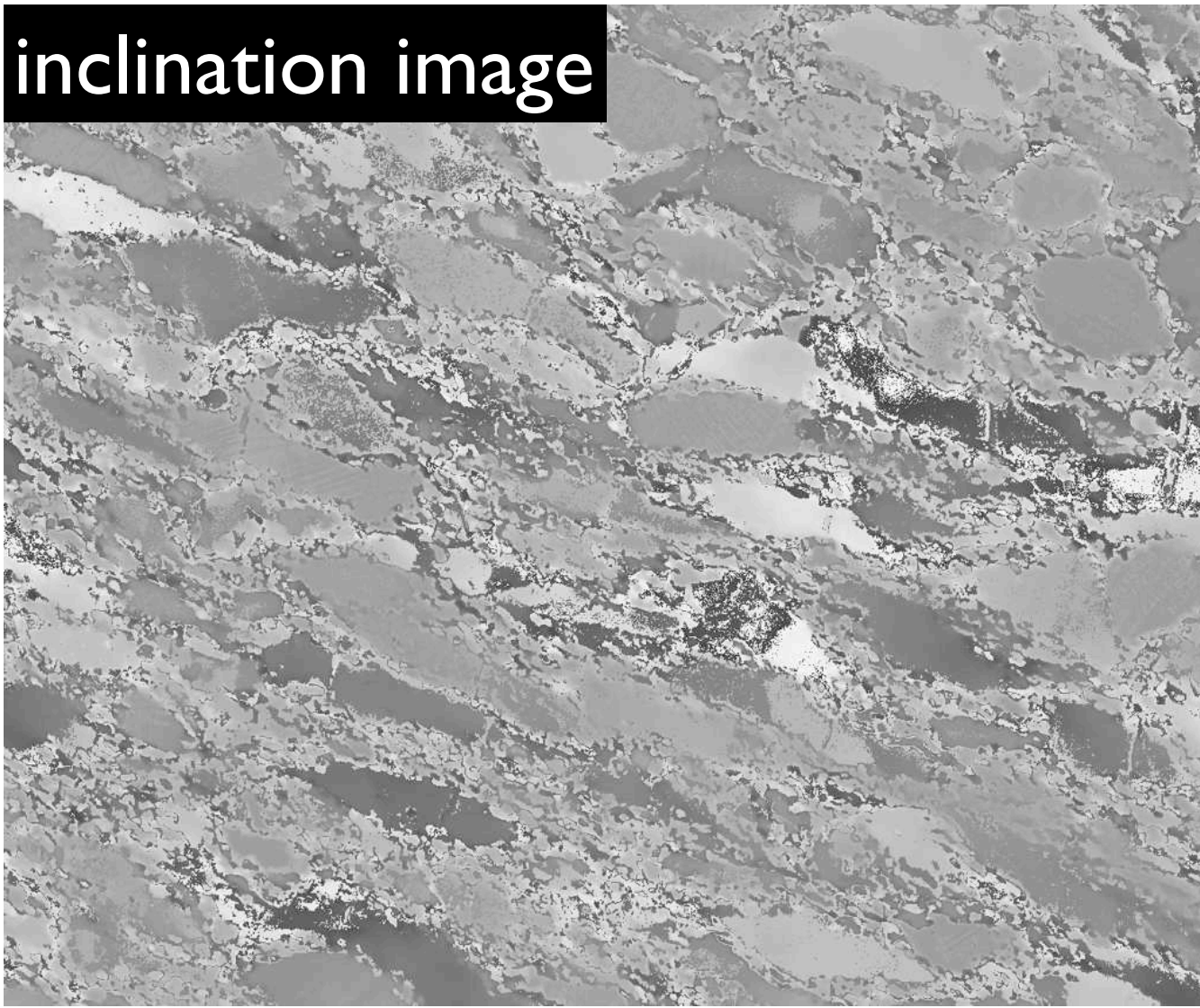
**Figure 22.33**

Viewing the azimuth image (AZI).

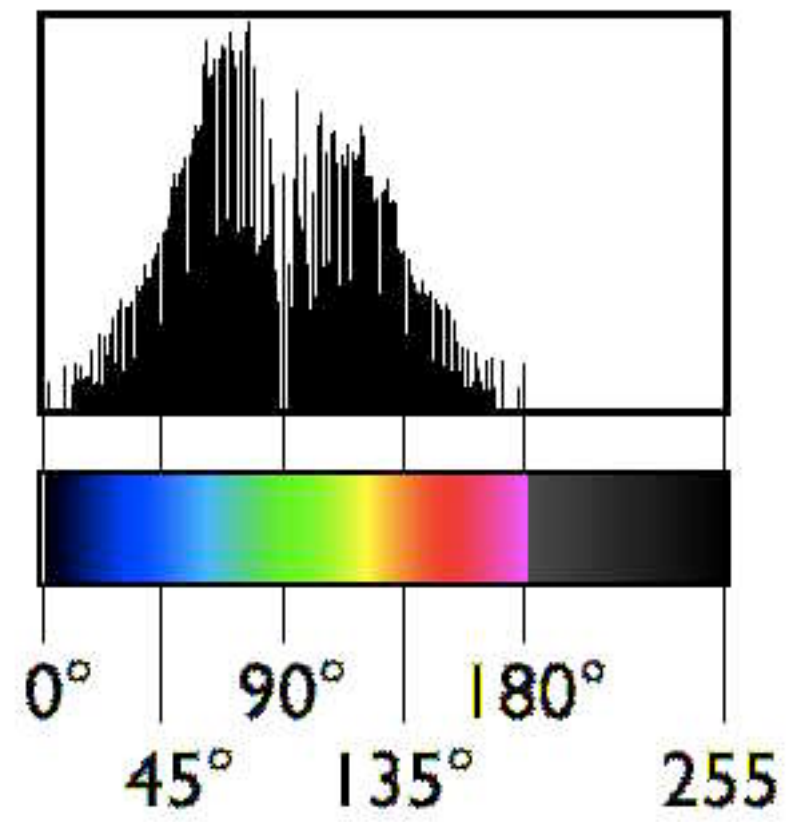
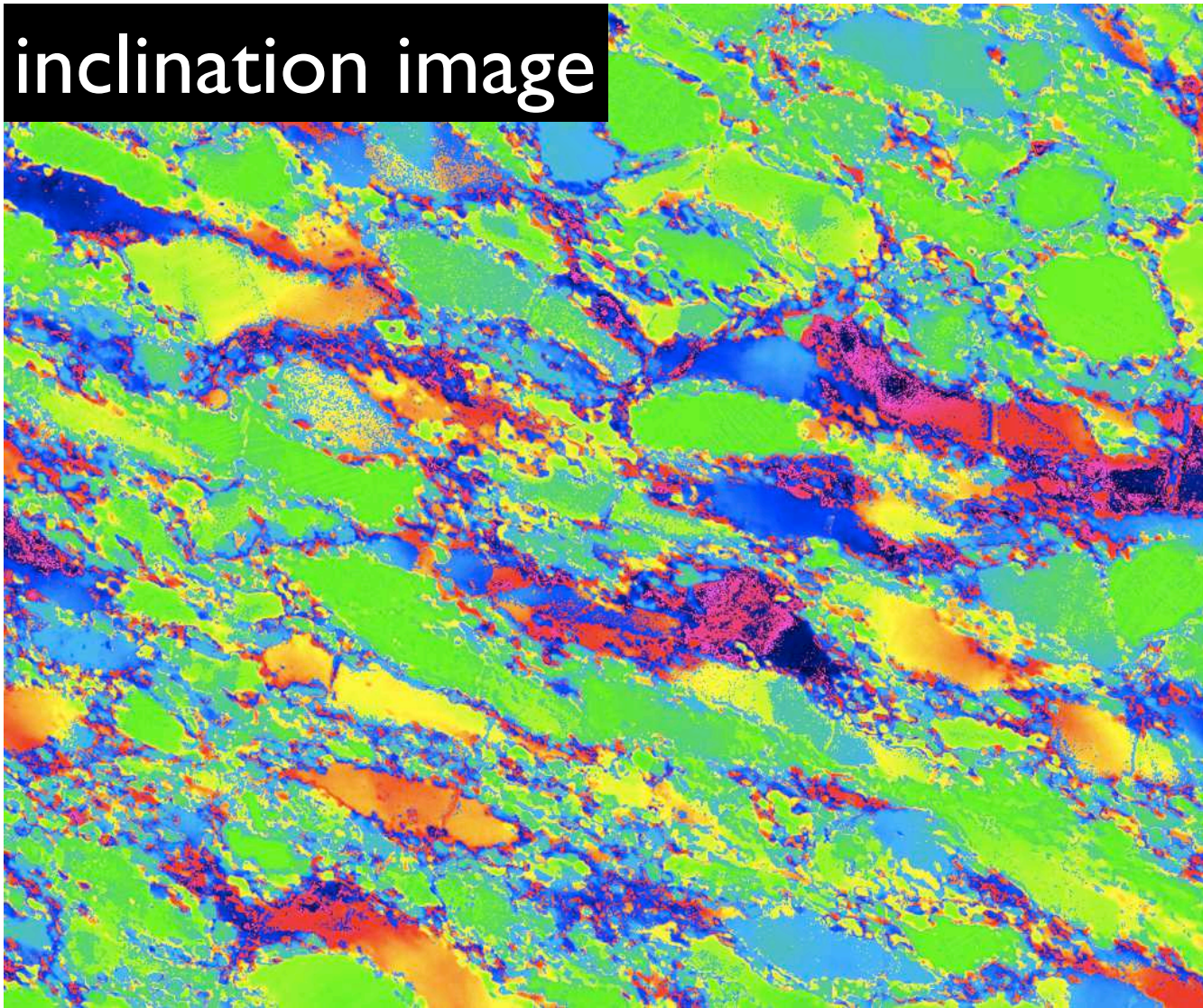
The look-up table (LUT) runs from black and blue hues (indicating North) to red hues and black again (indicating South); LUT wraps around. Dominant blue indicates preferred orientation around 45° of azimuth.



inclination image



inclination image



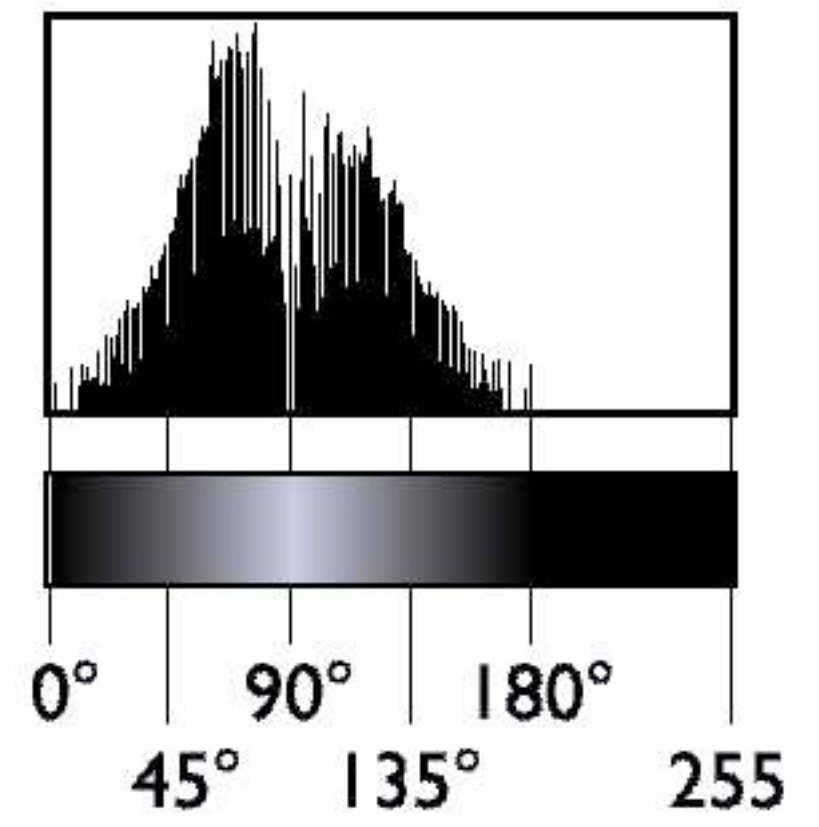
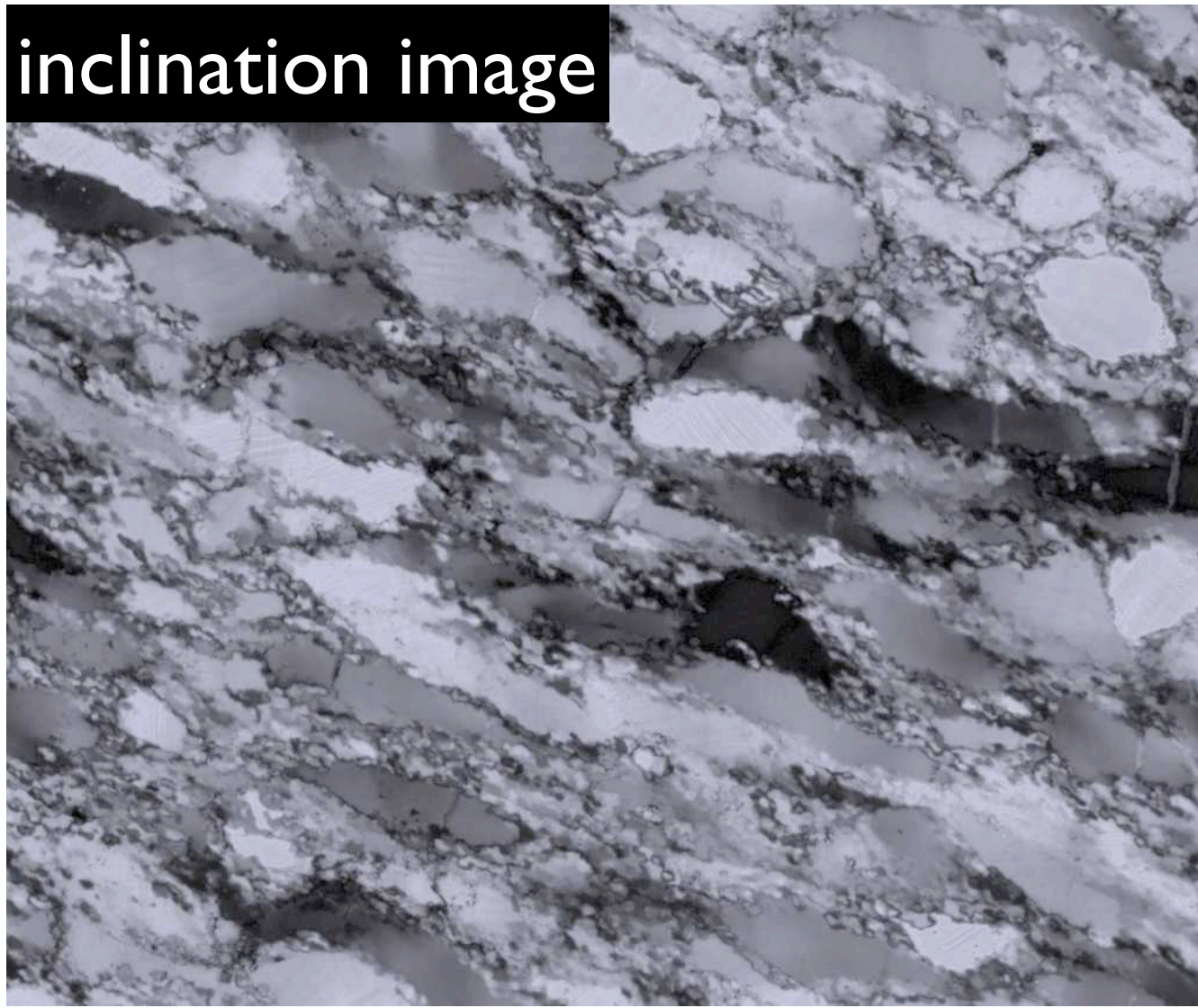
**Figure 22.34**

Viewing the inclination image (INC).

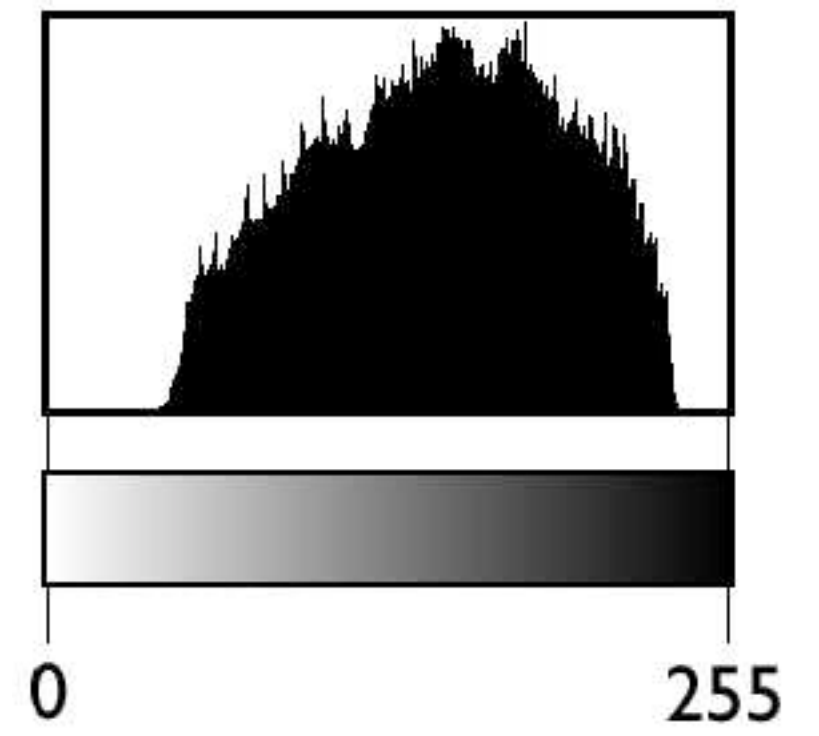
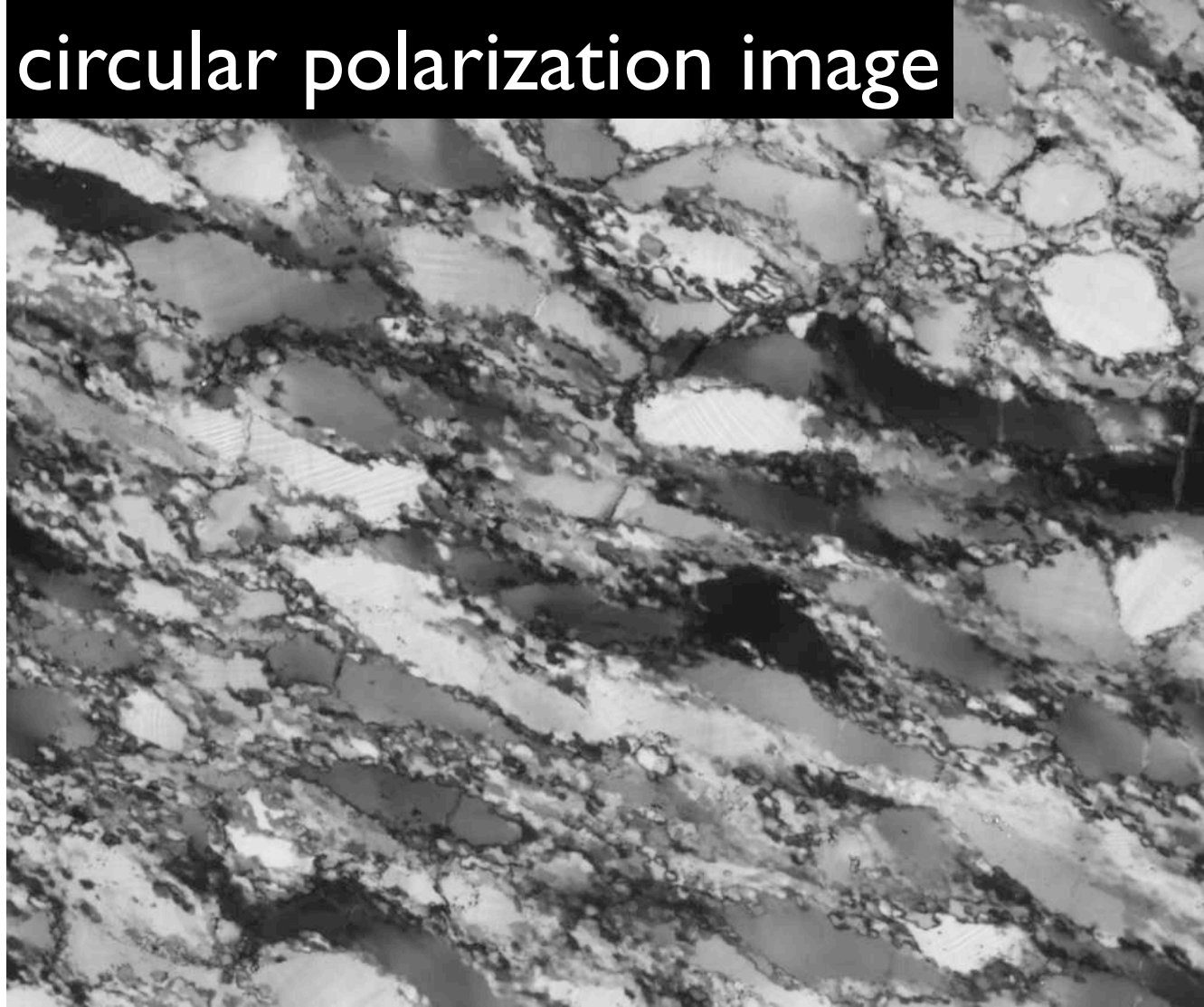
The look-up table (LUT) runs from black (indicating Heaven or Up) to red and purple hues (indicating Hell or Down); LUT does not wrap around. Dominant green indicates preferred inclinations of 90°, i.e., close to image plane.



inclination image



circular polarization image

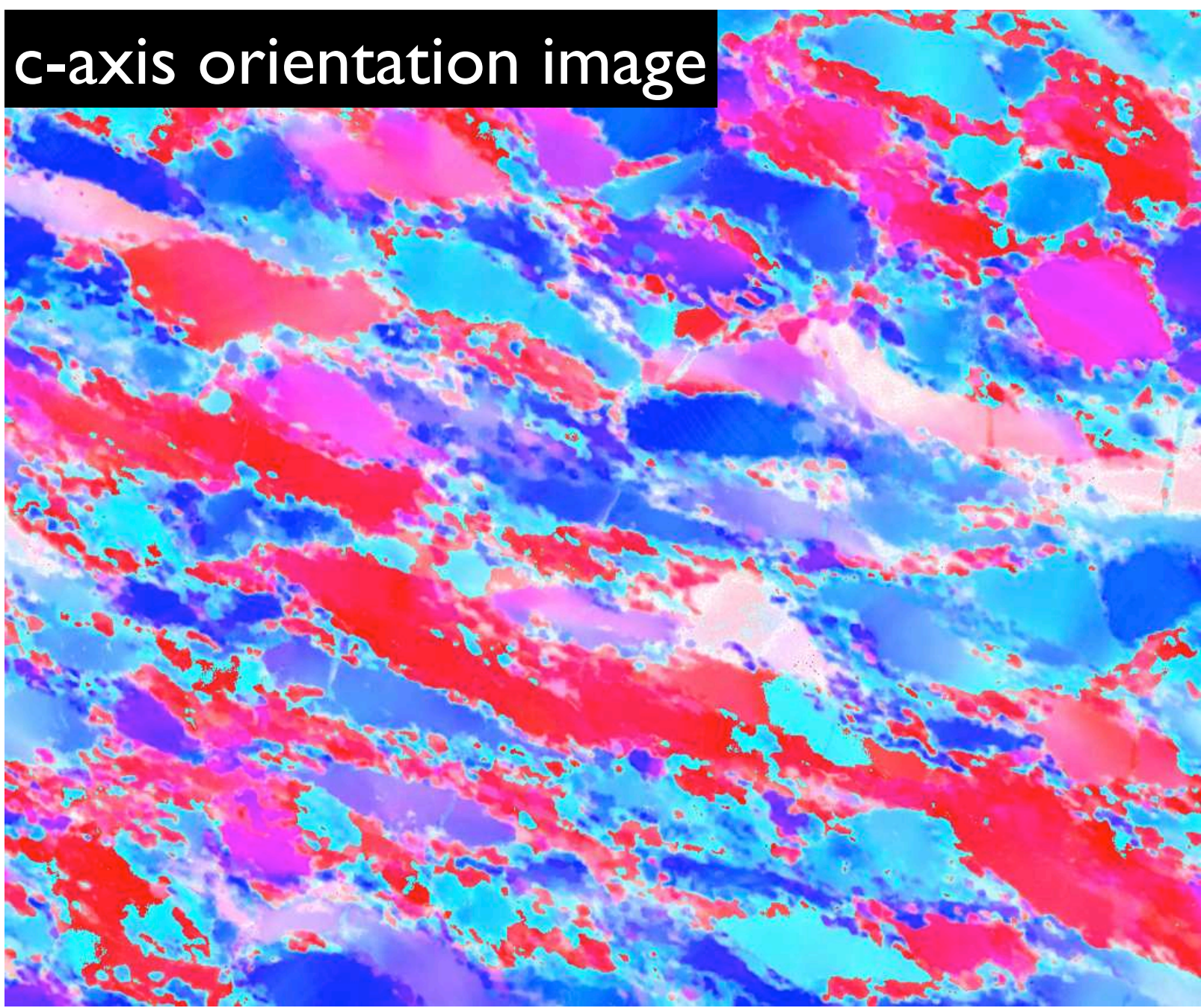


**Figure 22.35**

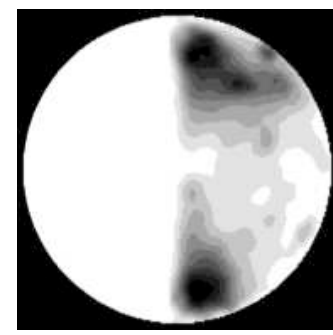
Comparing the inclination image to circular polarization.

The look-up table displays the inclination image (Figure 22.22) as the thin section would appear under circular polarization.



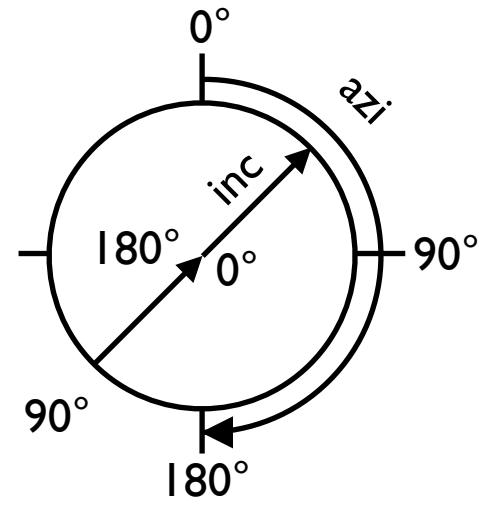
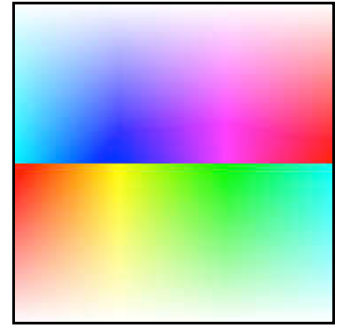
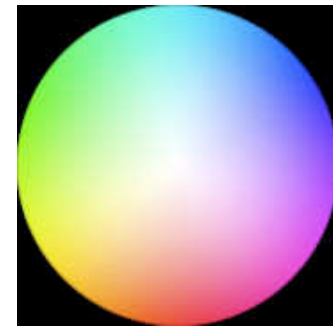


c-axis orientation image



$(0^\circ \leq \text{INC} \leq 90^\circ)$

Standard CLUT

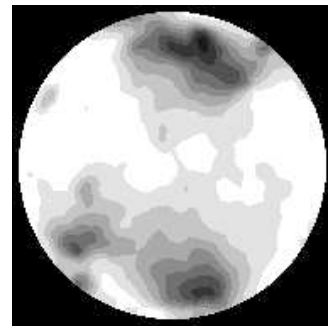
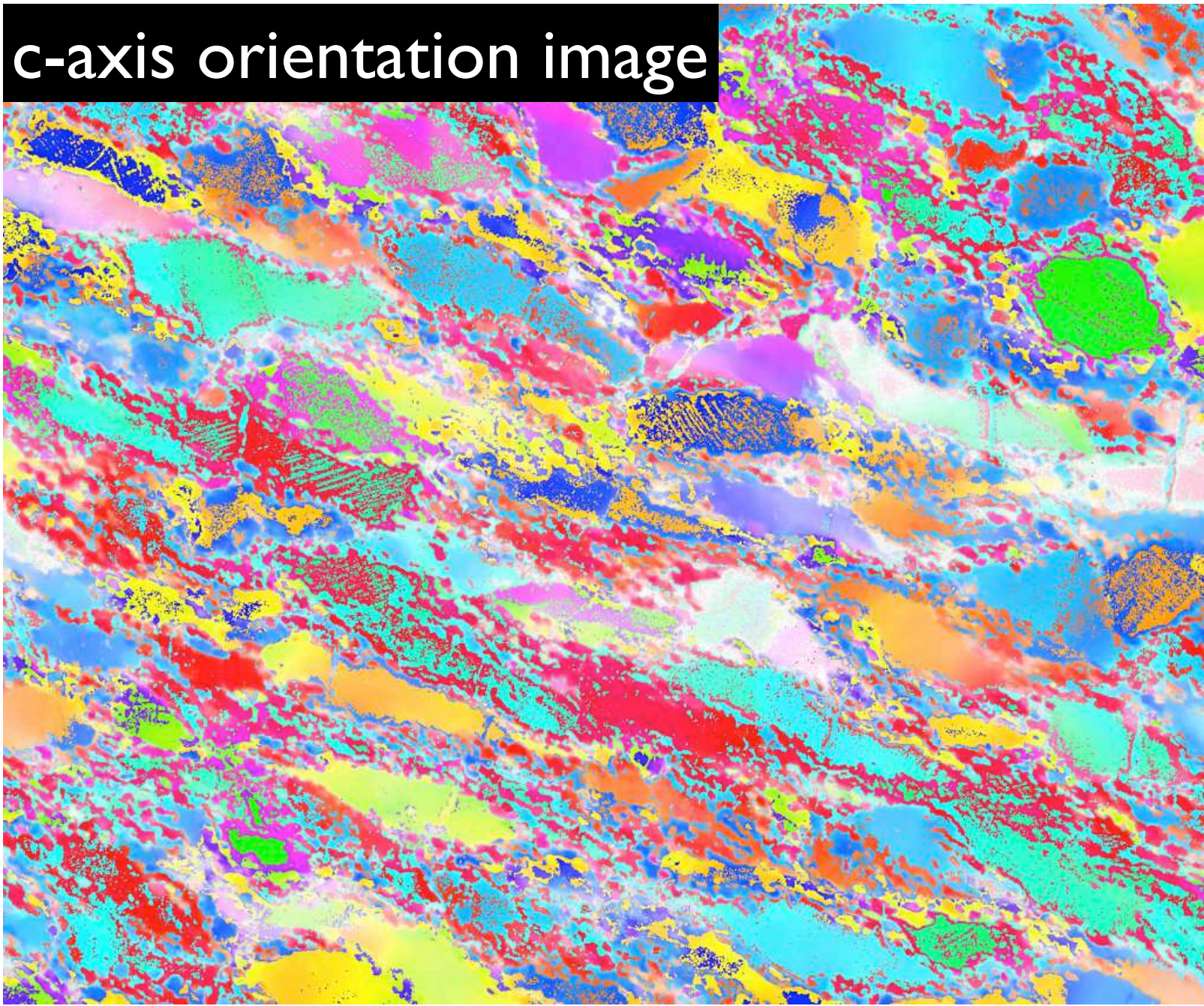


**Figure 22.36**

Partial c-axis orientation image (COI) for primary inclinations. Left: COI, right: corresponding pole figure. Two representations of the color look-up table (CLUT) (compare Figure 22.6).

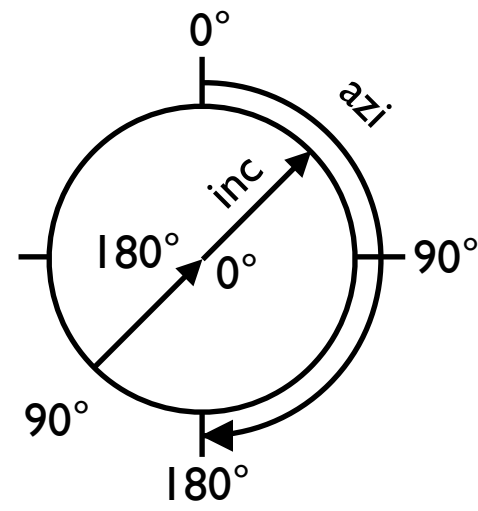
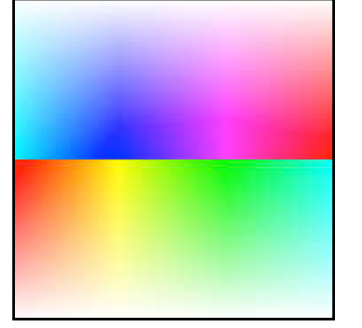
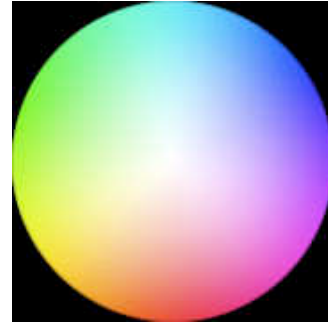


c-axis orientation image



$(0^\circ \leq \text{INC} \leq 180^\circ)$

Standard CLUT

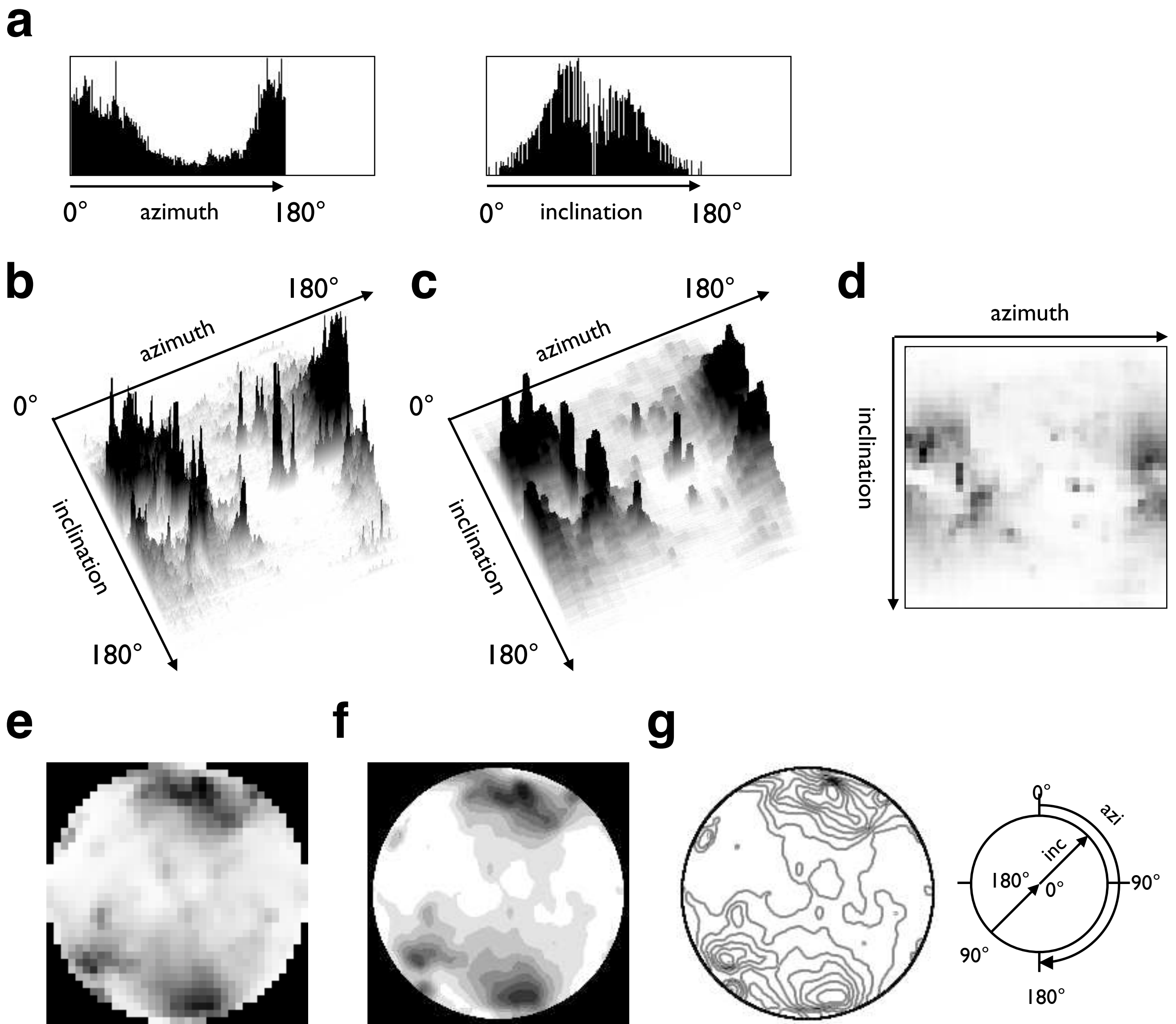


**Figure 22.37**

The c-axis orientation image (COI).

Left: COI, right: corresponding pole figure. The color look-up table (CLUT) displays every orientation with a unique color thus generating artificial contrast for flat lying axis dipping above and below the image plane.





**Figure 22.38**

Pole figures from azimuth and inclination image.

(a) Histograms of azimuth and inclination images;

(b) 2-D histogram of azimuth and inclination,  $1^\circ$  binning;

(c) 2-D histogram of azimuth and inclination,  $5^\circ$  binning;

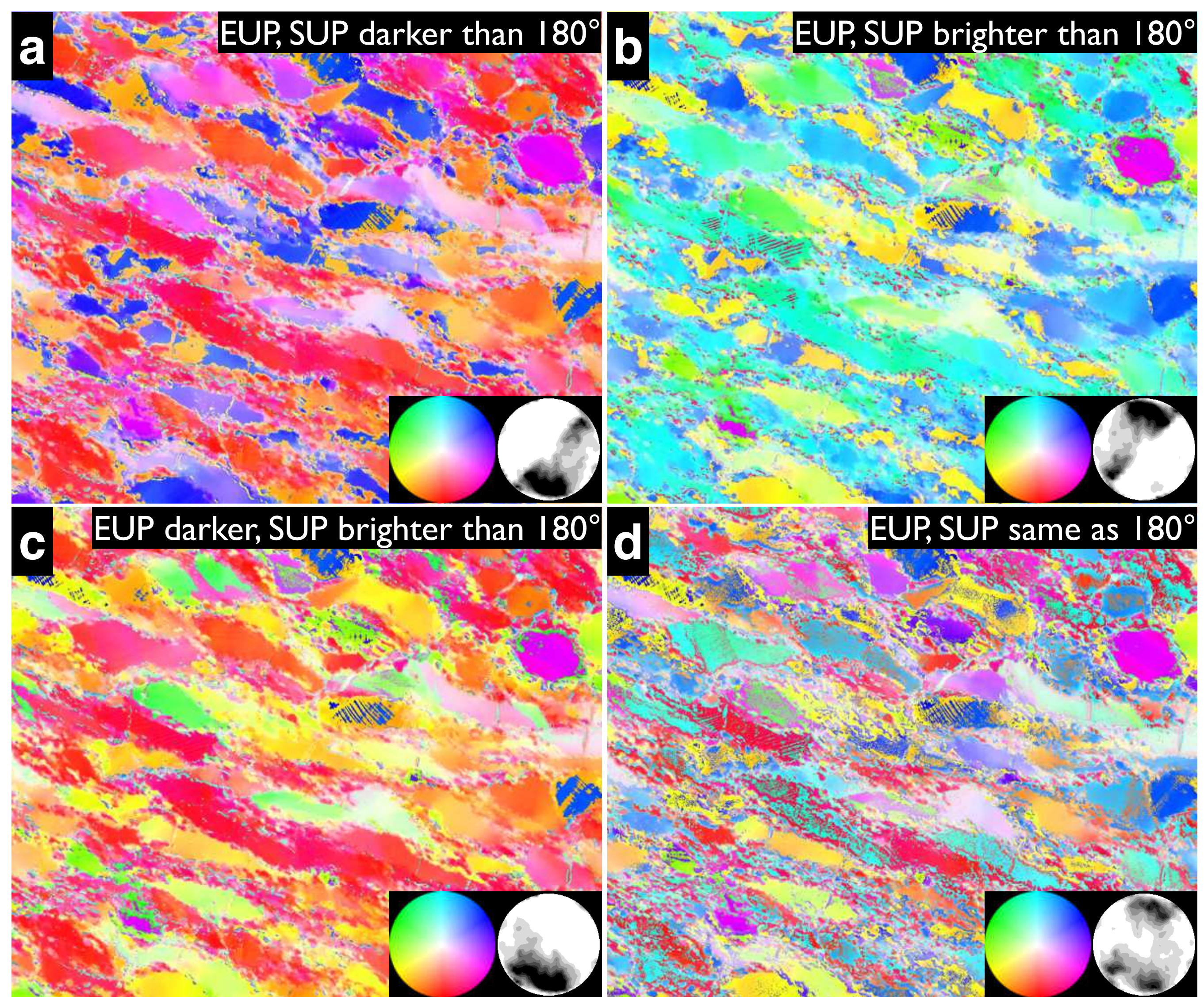
(d)  $36 \cdot 36$  pixel matrix of (c);

(e) stereographic projection of (d) (Schmidt net, upper hemisphere);

(f) magnified version of (e) created with the Lazy pole macro (see Software Box 22.1, part 2) with stepped gray levels (1 step = 0.5 times uniform);

(g) contour version of (f).





**Figure 22.39**

Effect of not matching the tilt images to the  $180^\circ$  rotation image.

The gray value averages of the images are:

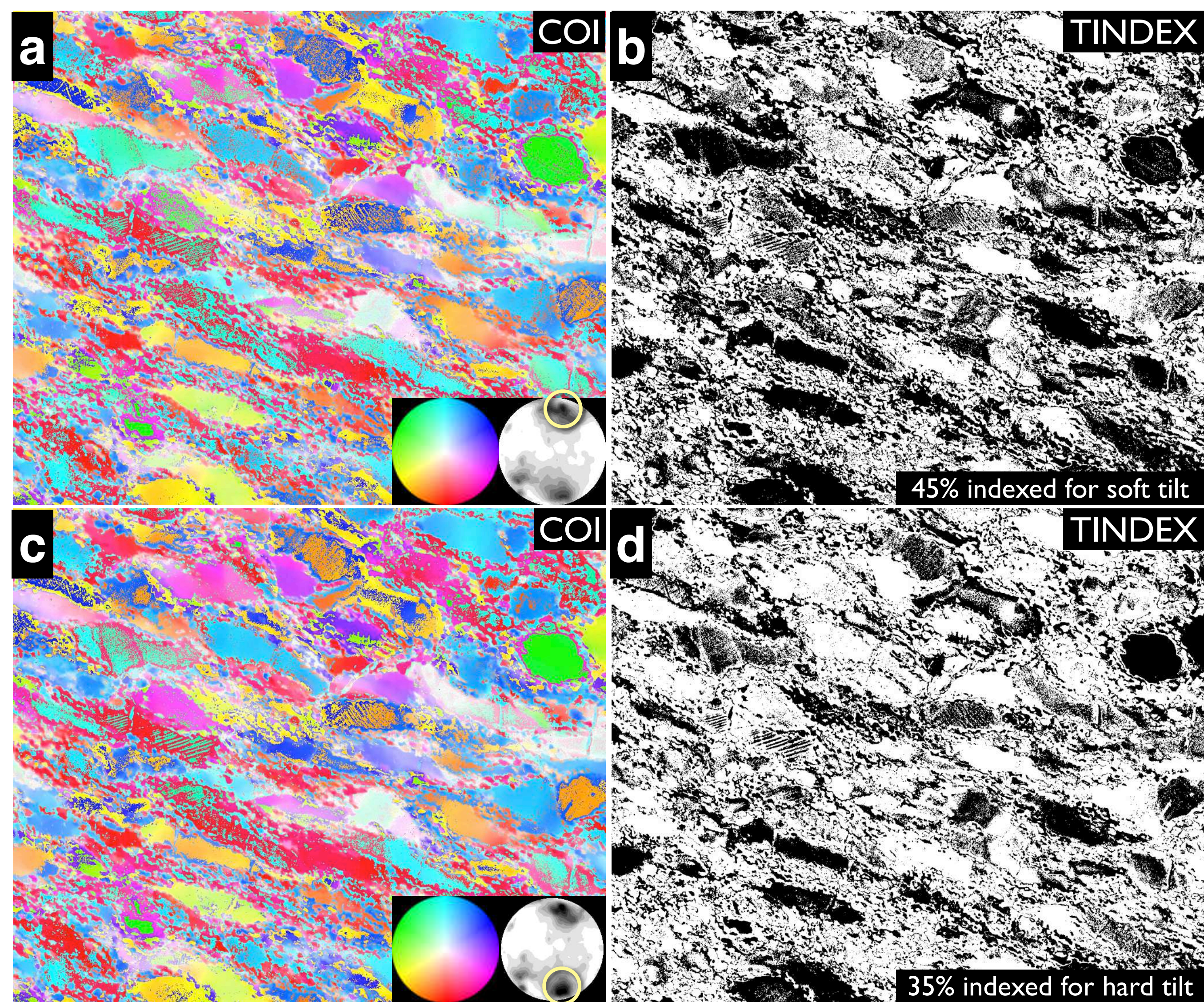
(a) rotation  $180^\circ = 172$ ; EUP = 182; SUP = 182;

(b) rotation  $180^\circ = 172$ ; EUP = 162; SUP = 162;

(c) rotation  $180^\circ = 172$ ; EUP = 182; SUP = 162;

(d) rotation  $180^\circ = 172$ ; EUP = 172; SUP = 172.





**Figure 22.40**

Effect of soft and hard tilt corrections.

Left: c-axis orientation image (COI); right: tilt index file (TINDEX).

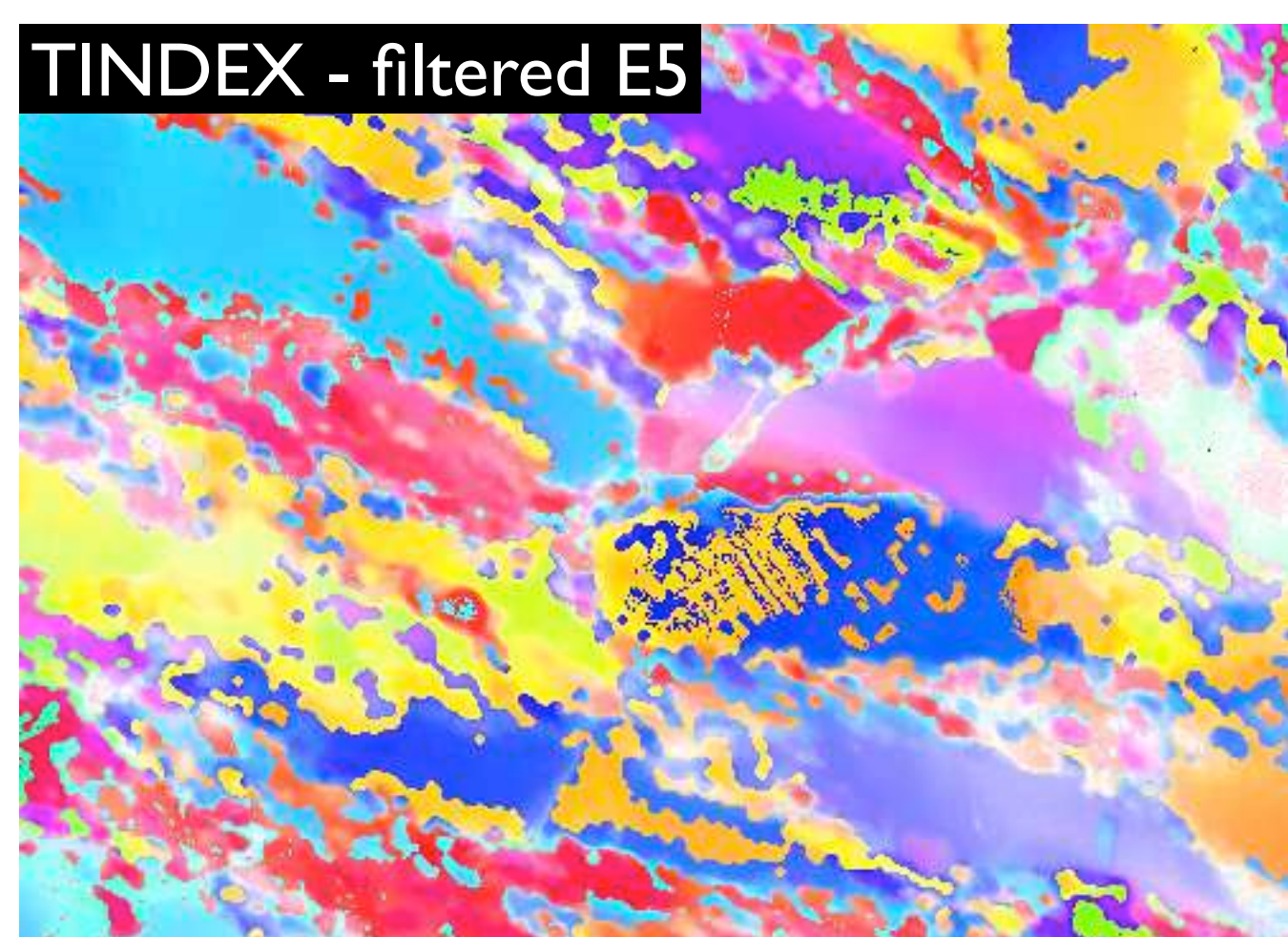
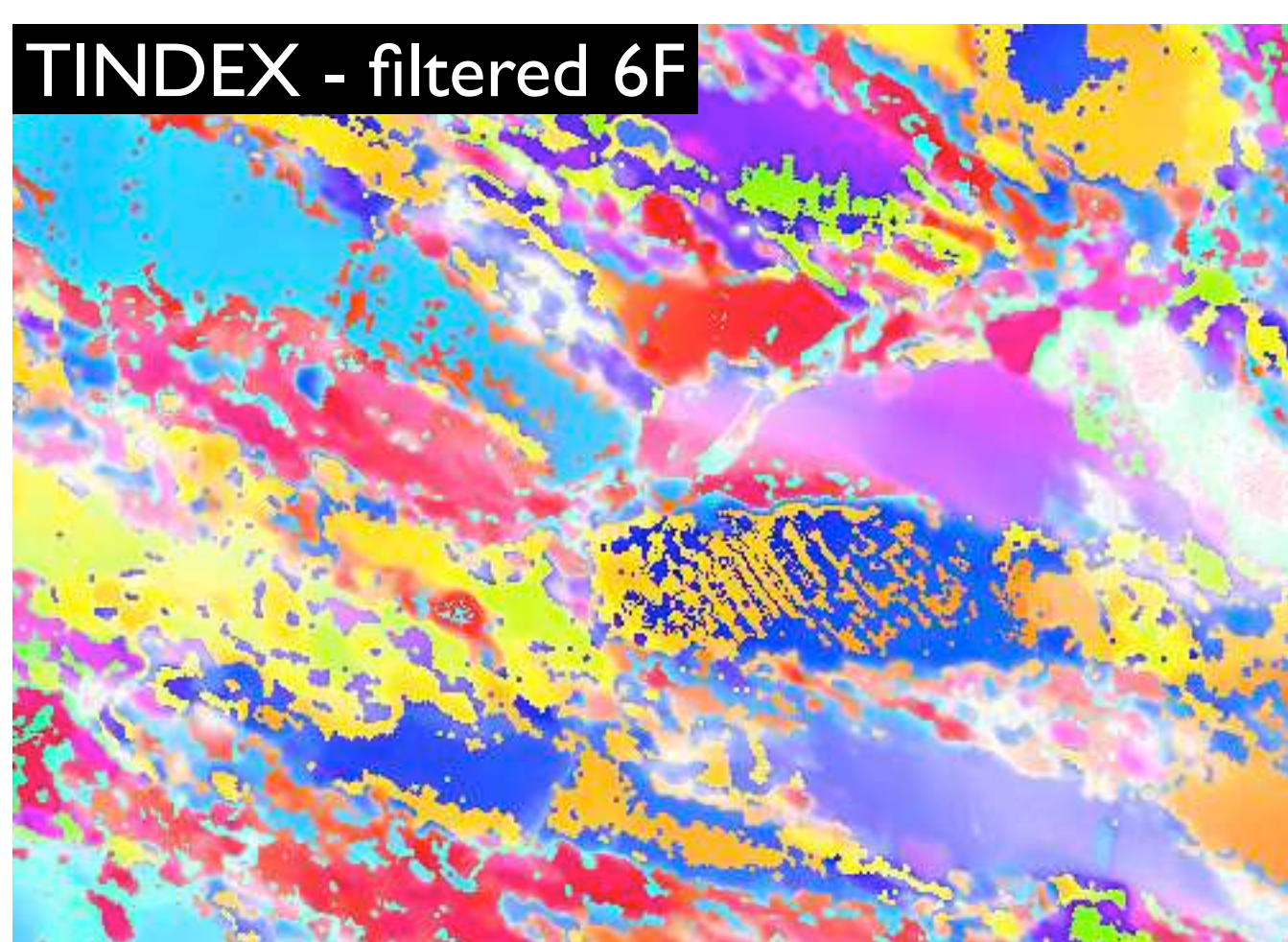
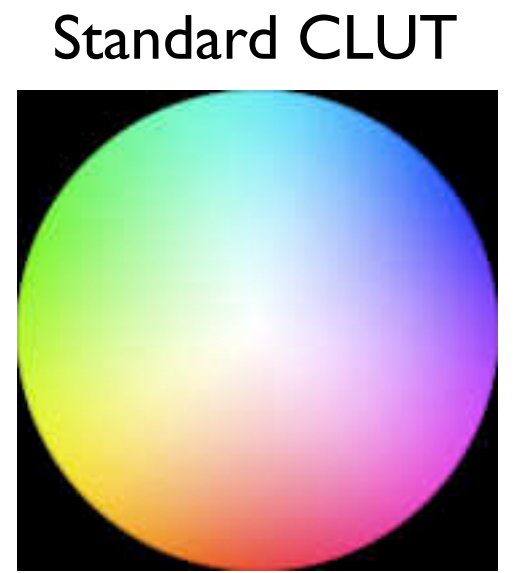
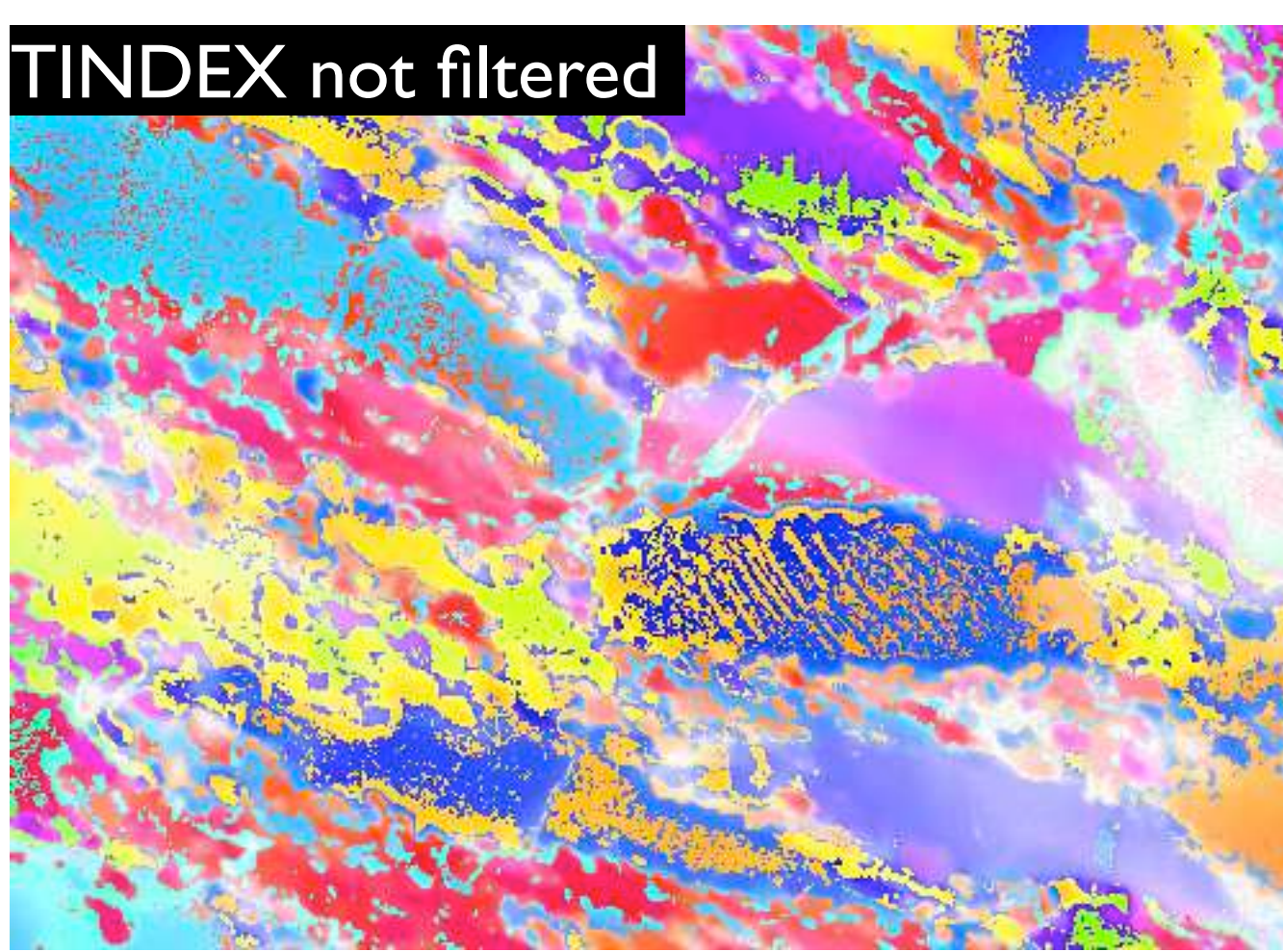
If pixel in TINDEX is black, primary inclination is converted to (180°-primary), and c-axis moves to left side of pole figure. Soft Tilt: inclination is flipped if either EUP or SUP indicate tilt correction; Hard Tilt: inclination is flipped if both EUP and SUP indicate tilt correction.

(a) COI and TINDEX for Soft Tilt;

(b) COI and TINDEX for Hard Tilt.

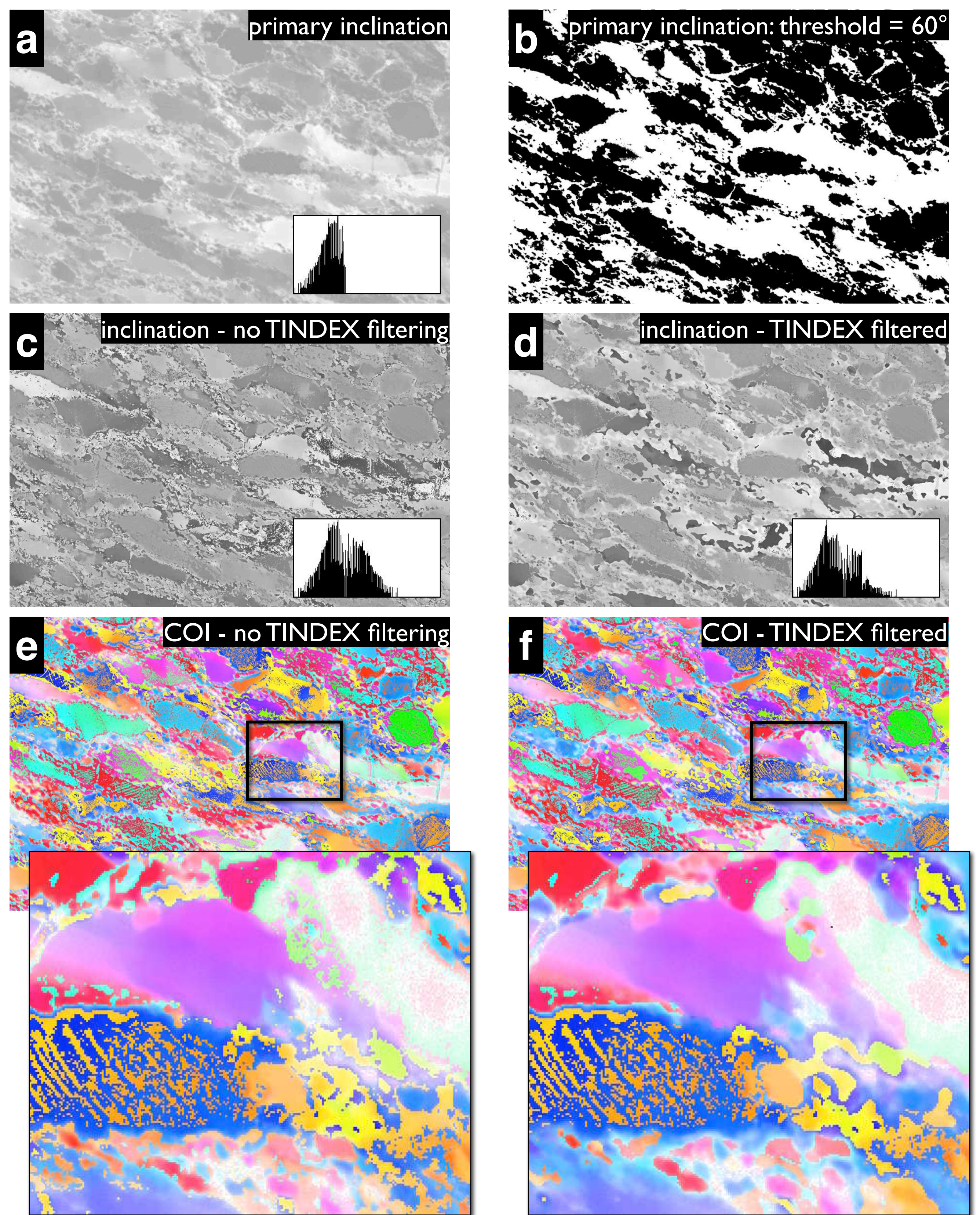
Note higher fraction of tilt corrections for Soft Tilt (45%) compared to Hard Tilt (35%); note also difference of resulting pole figures; maximum is highlighted.





**Figure 22.41**  
Effect of structural filtering of tilt index image (TINDEX).  
Detail of c-axis orientation image, obtained from CIP calculation using unfiltered TINDEX (top) and filtered TINDEX (bottom);  
6F filtering: erosion and dilation of TINDEX image with neighbor setting 6;  
5E filtering: erosion and dilation of TINDEX image with neighbor setting 5 - stronger effect.



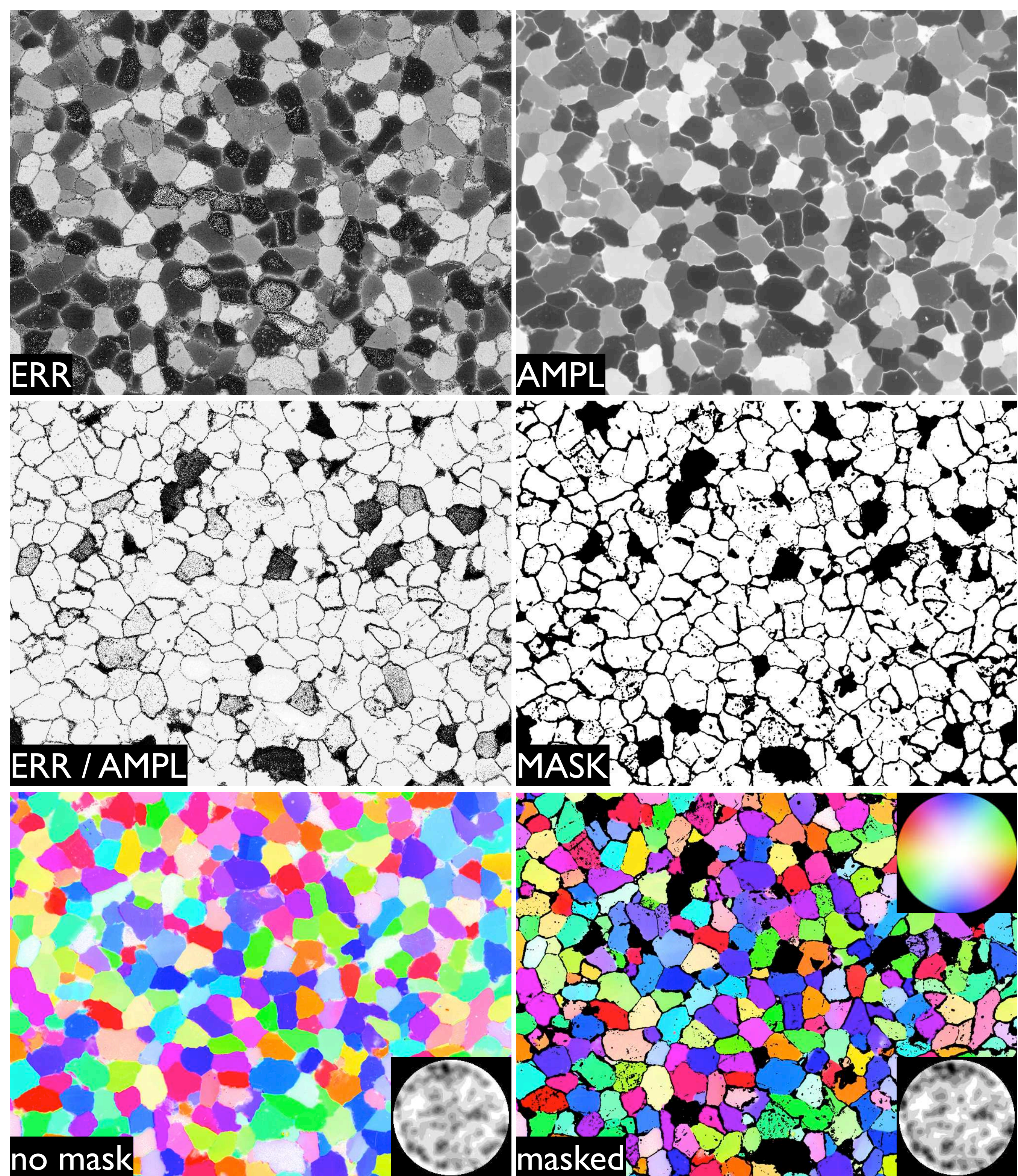


**Figure 22.42**

Selective filtering of tilt index file (TINDEX ).

Primary inclination image (a) is used to create a mask for steep axes, i.e., inclinations  $< 60^\circ$  (b); low inclinations are filtered heavily using neighbor setting of 4, high inclinations (flat lying axes) are left unfiltered (d); unfiltered inclination image is shown for comparison (c). The resulting c-axis orientation images (COI) and detail views of unfiltered and filtered TINDEX images are shown in (e) and (f), respectively.





**Figure 22.43**

Making masks from error images.

A quality mask is obtained by dividing the error image (ERR) by the amplitude (AMPL) (see Figure 22.27) and thresholding.

ERR = err image; AMPL = (MAX-MIN) = amplitude of rotation signal; ERR/AMPL = Real Result of division by 'Image Math...' command in Process menu; MASK = thresholded version of ERR/AMPL.

Two c-axis orientation images of undeformed Black Hills quartzite are shown with and without mask; comparison of pole figure shows slightly reduced density in center (low inclination, isotropic orientation) for masked version.