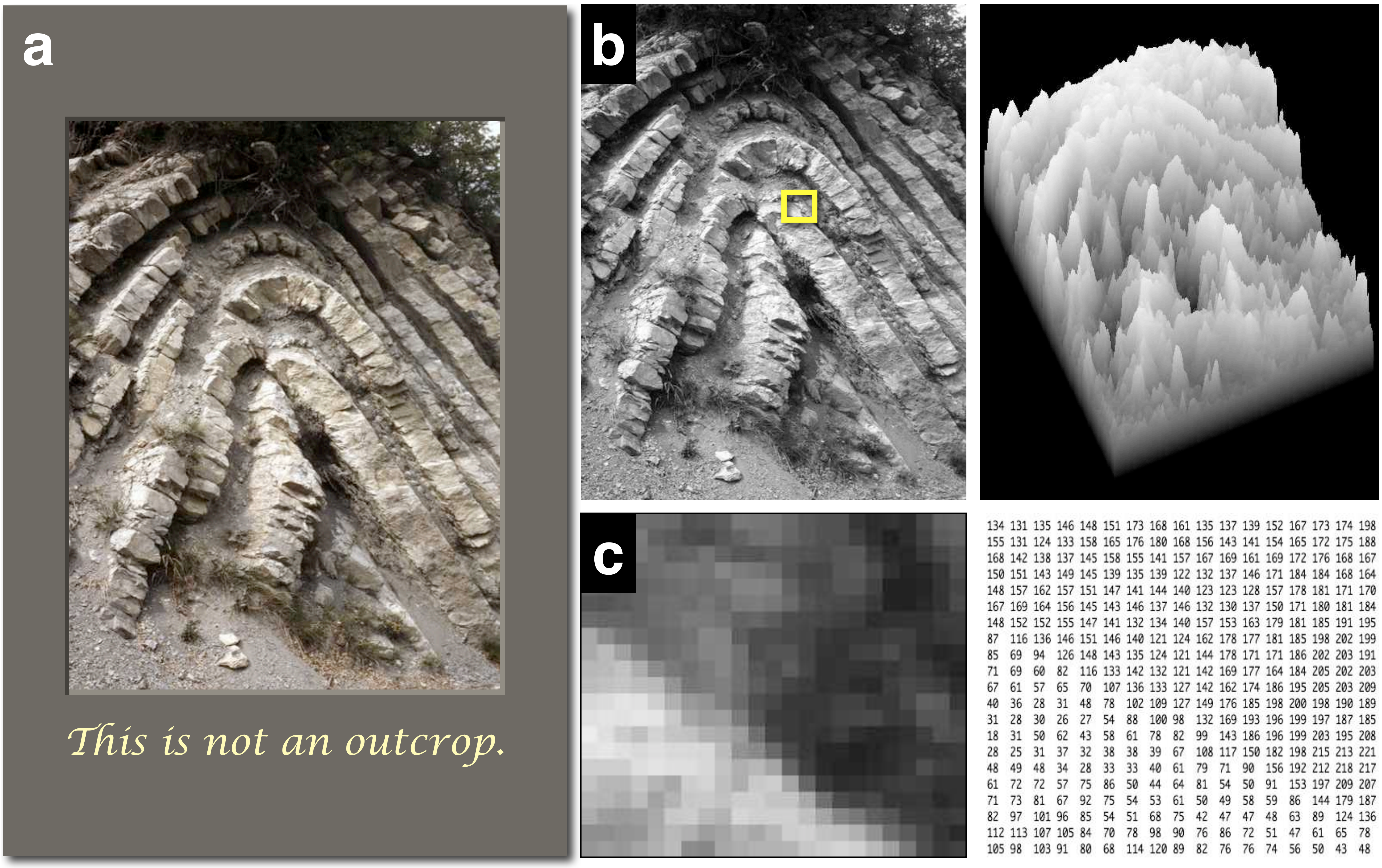

This is not an outcrop.

Figure 1.1
Images are not objects.
(a) Following René Magritte's famous painting 'Ceci n'est pas une pipe', this picture points to the fact that a picture is not what it represents.
(b) To bring out the nature of images, the picture is shown as a monochrome image and as a 3-D rendition of the brightness distribution.
(c) To demonstrate what digital images 'really are', the number matrix for a small detail (frame in (b)) is shown also.

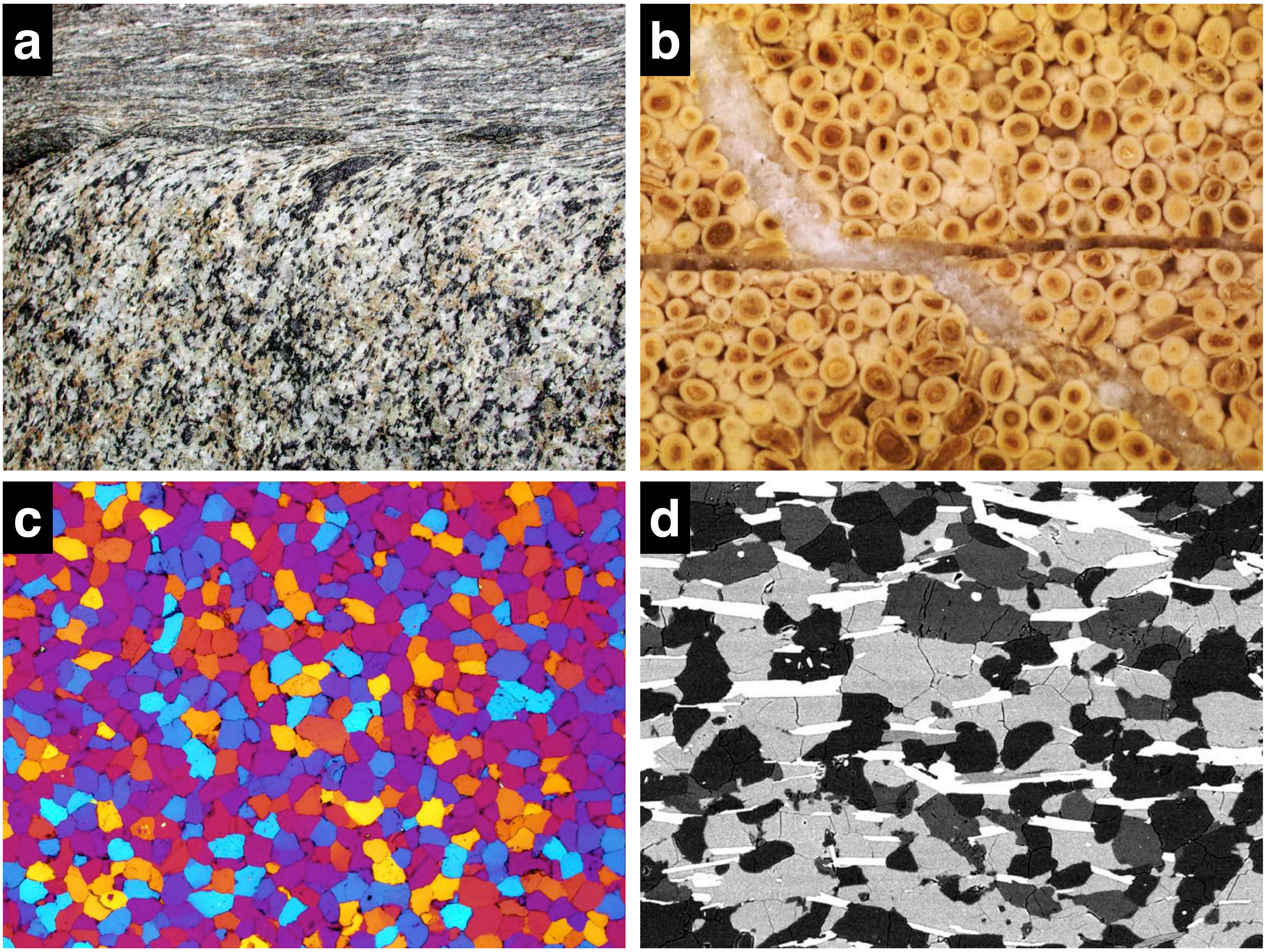

Figure 1.2
Typical input for image analysis.
(a) Photomacrograph of glacially polished surface of shear zone and wall rock;
(b) photomacrograph of polished surface of oolithic limestone;
(c) micrograph of thin section of quartzite, cross polarization and wave plate;
(d) scanning electron micrograph of polished surface of granitic rock, with back-scattered electron contrast (Image courtesy Rüdiger Kilian).

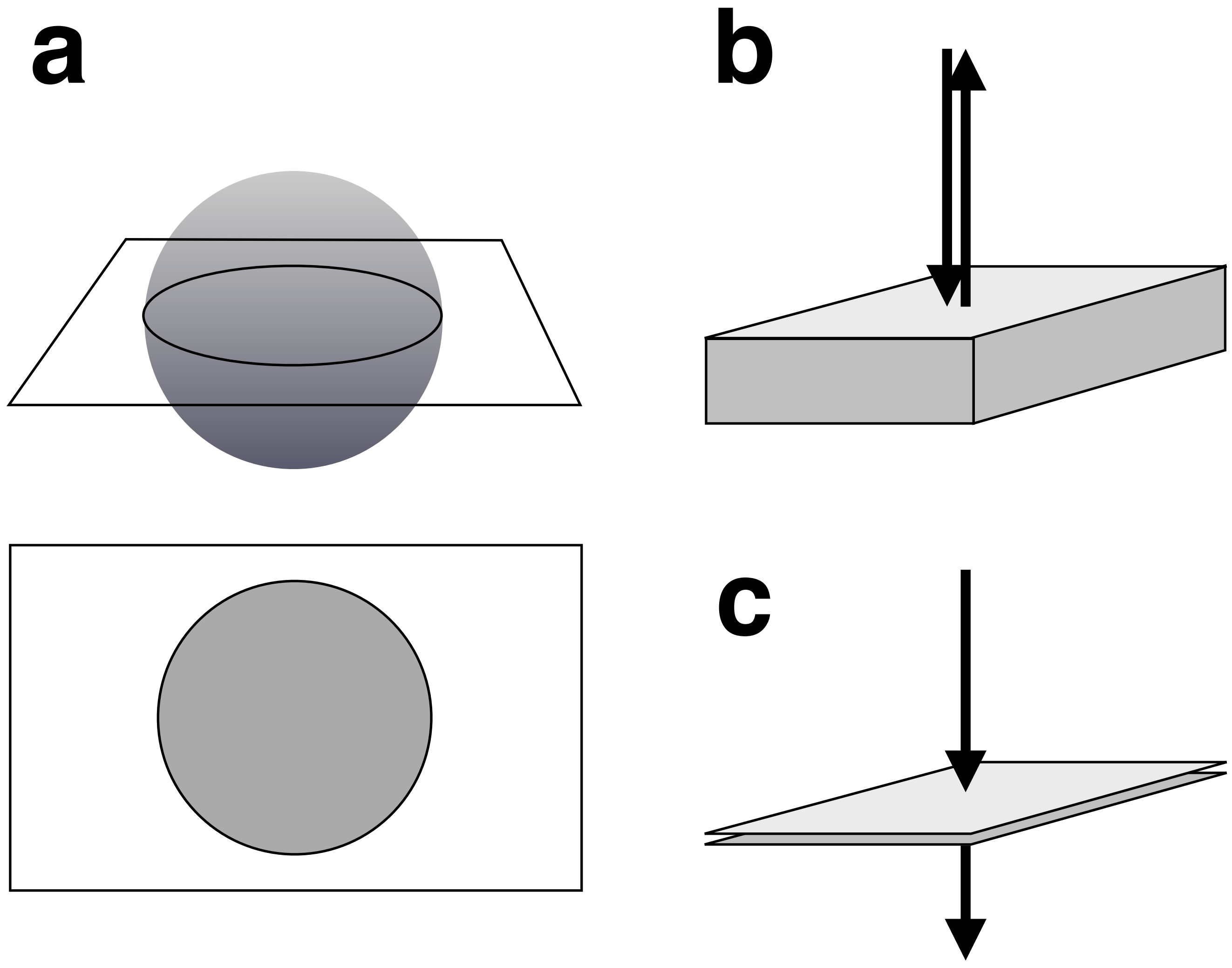

Figure 1.3
2-D section of 3-D body.
(a) Concept of a perfect 2-D section: section thickness = 0;
(b) surface (= plane) imaged in incident mode;
(c) section (= very thin volume) imaged in transmitted mode.

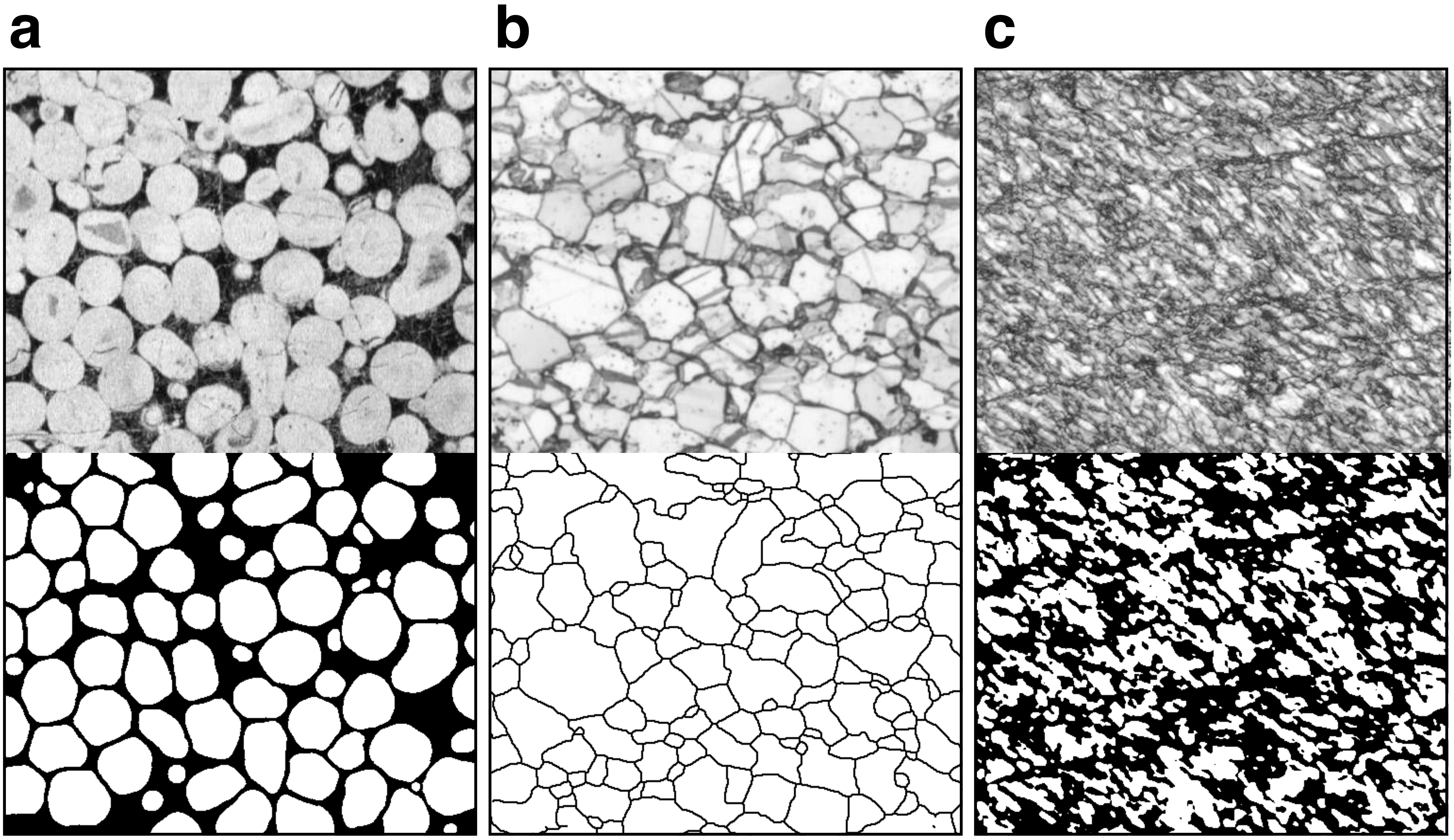

Figure 1.4
Type microstructures for image analysis.
The grayscale micrographs are shown on top; the model microstructures are shown below.
(a) In the particles-in-matrix type, two visually discernible phases exist: particles (white) and matrix (black);
(b) in the space-filling aggregate, only one (visual) phase is present: grains (white); there is no space between the grains; the outlines (black) do not represent a separate phase; they do not occupy any volume, they only denote the boundaries between grains;
(c) in the visual texture, the particles cannot be distinguished from one another; the model microstructure is a random pattern of black and white.

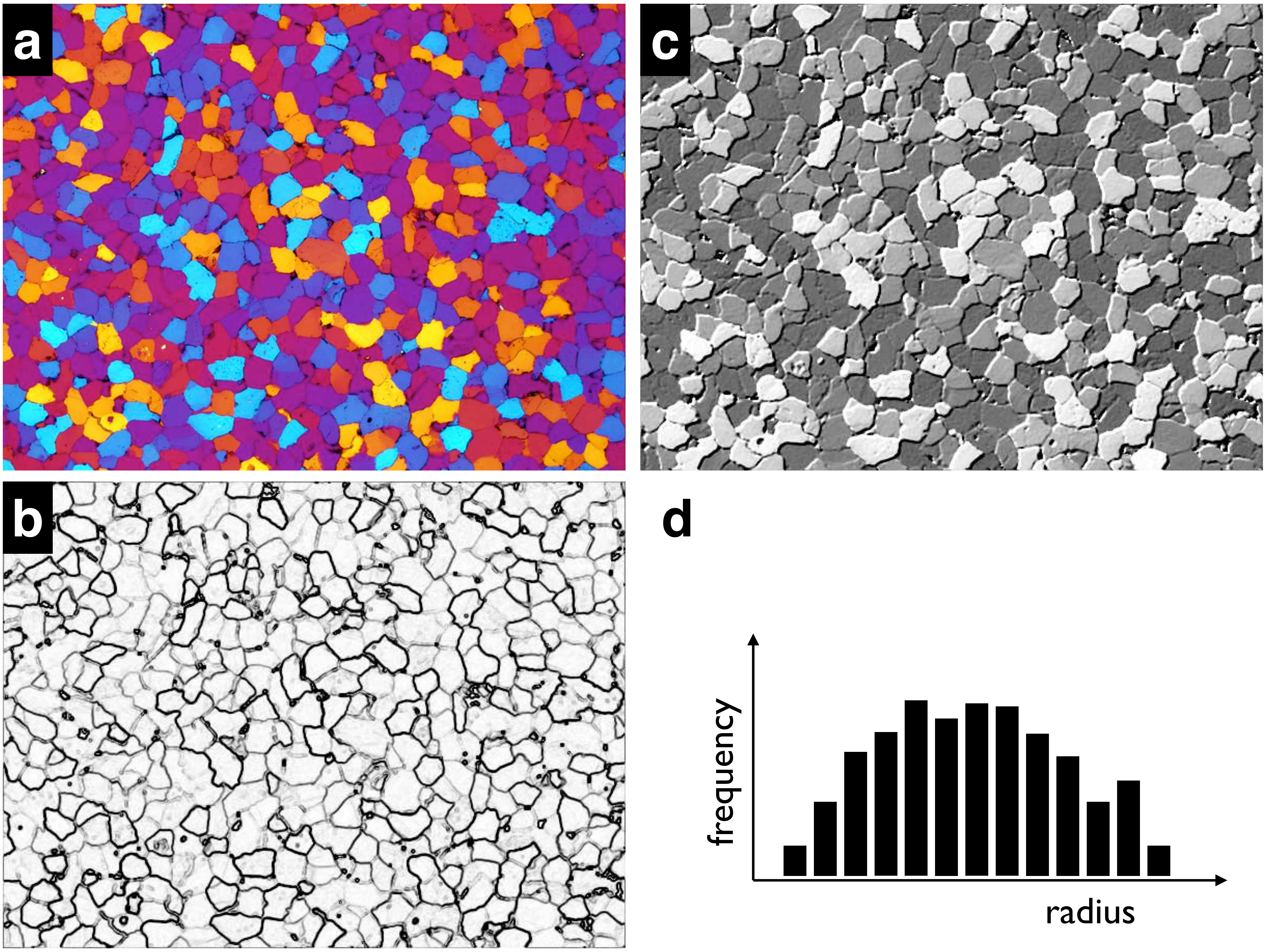

Figure 1.5
Image analysis versus image processing.
(a) Original image;
(b) result of image processing: image to image;
(c) result of image processing: image to image;
(d) result of image analysis: image to number(s).

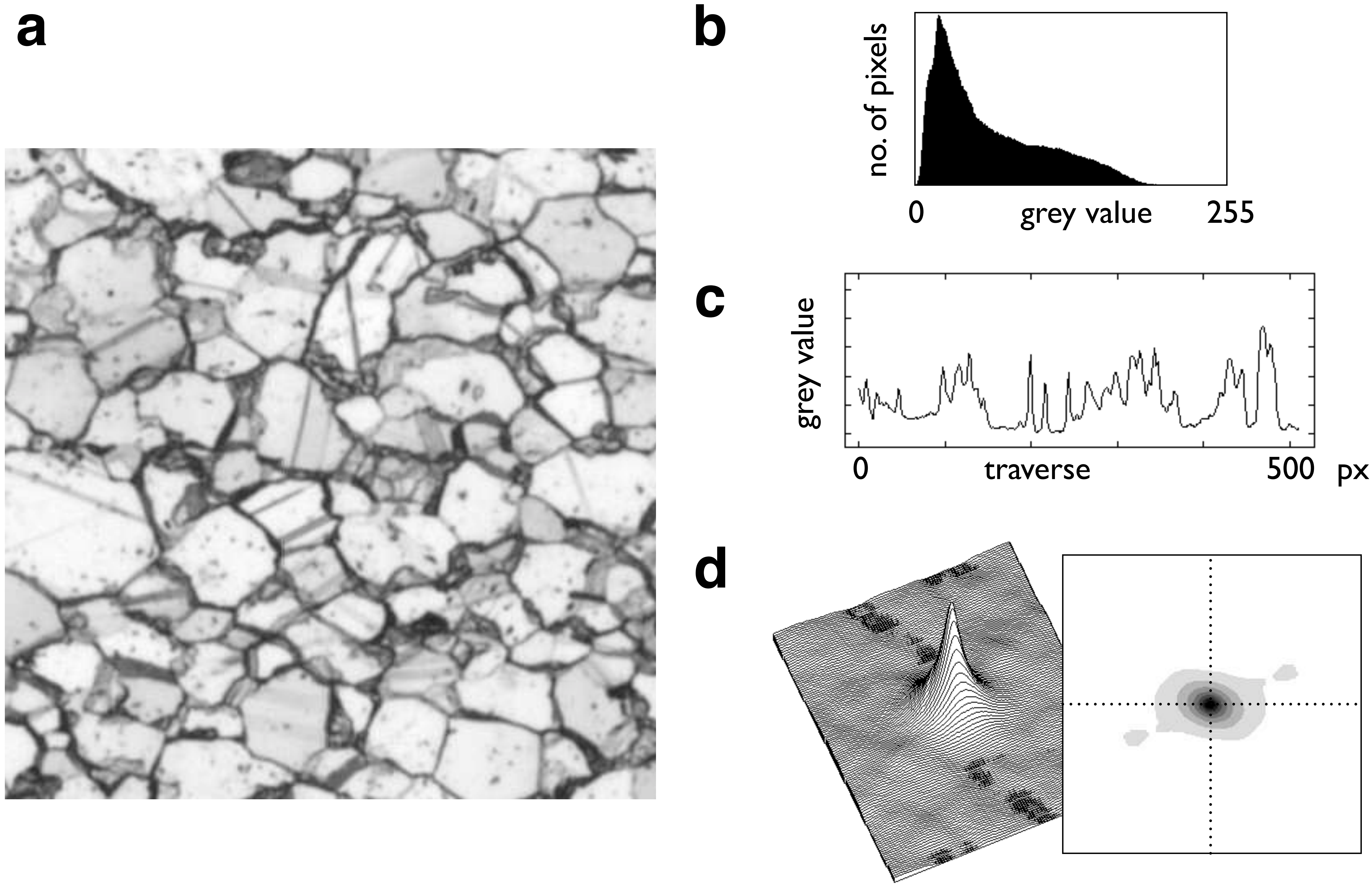

Figure 1.6
Direct image analysis.
(a) Image showing micrograph of marble in plane polarized light;
(b) statistics of gray values: histogram;
(c) spatial gray value changes: profile;
(d) correlation among gray values: autocorrelation function.

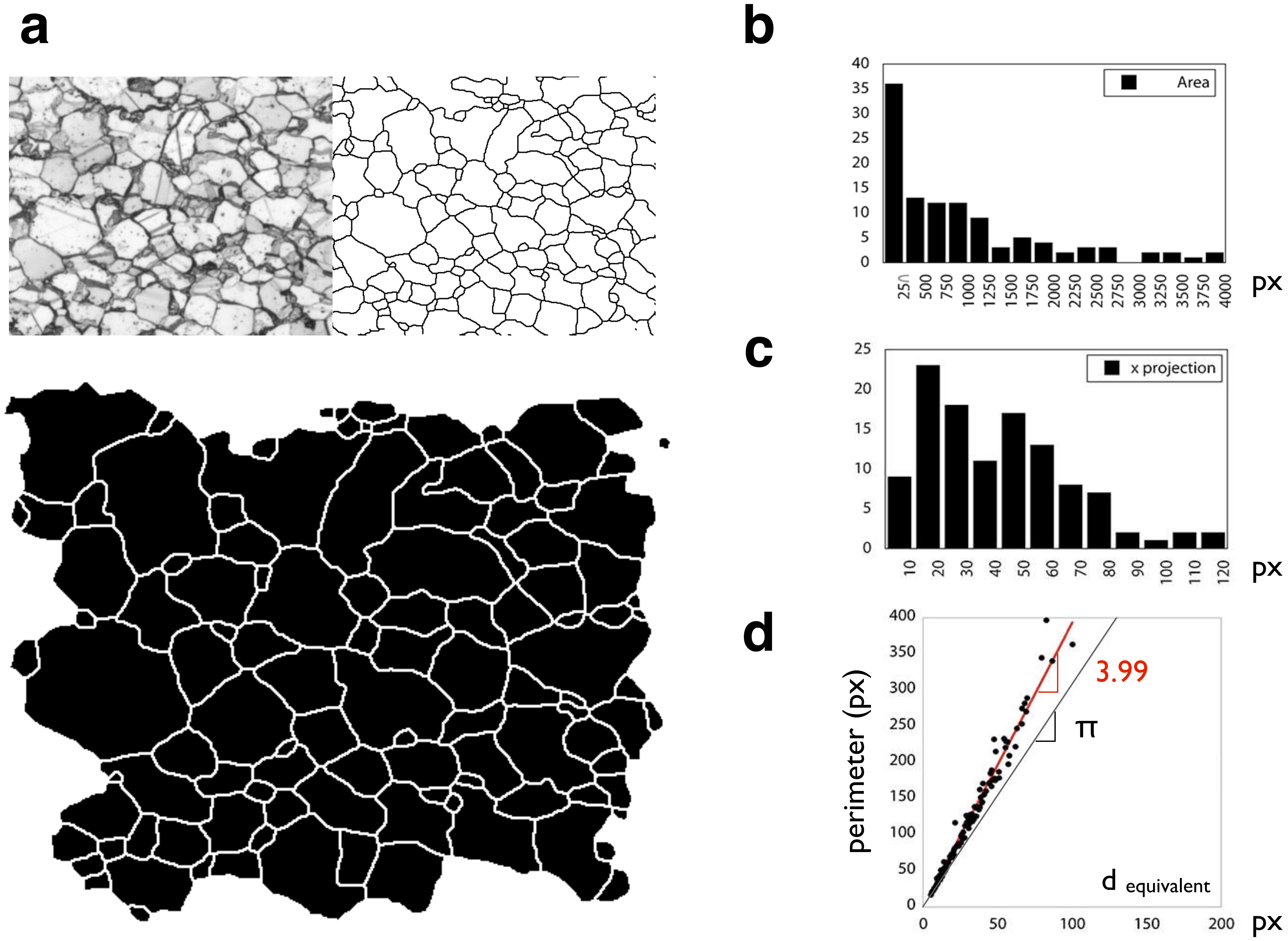

Figure 1.7
Image analysis using segments.
(a) Segmented image: cross sectional areas of calcite grains (original image and grain boundary map shown above);
(b) size distribution of segments: histogram of areas (= number of pixels per segment);
(c) projection of areas on x-axis (= difference between minimum and maximum x-coordinate, X_{max} - X_{min}, of each segment): histogram of lengths;
(d) length of perimeter of each segment (from number of boundary pixels) versus diameter of area equivalent circle, curve fit indicates a ratio of 3.99, slope π (= 3.14) for circle is indicated.

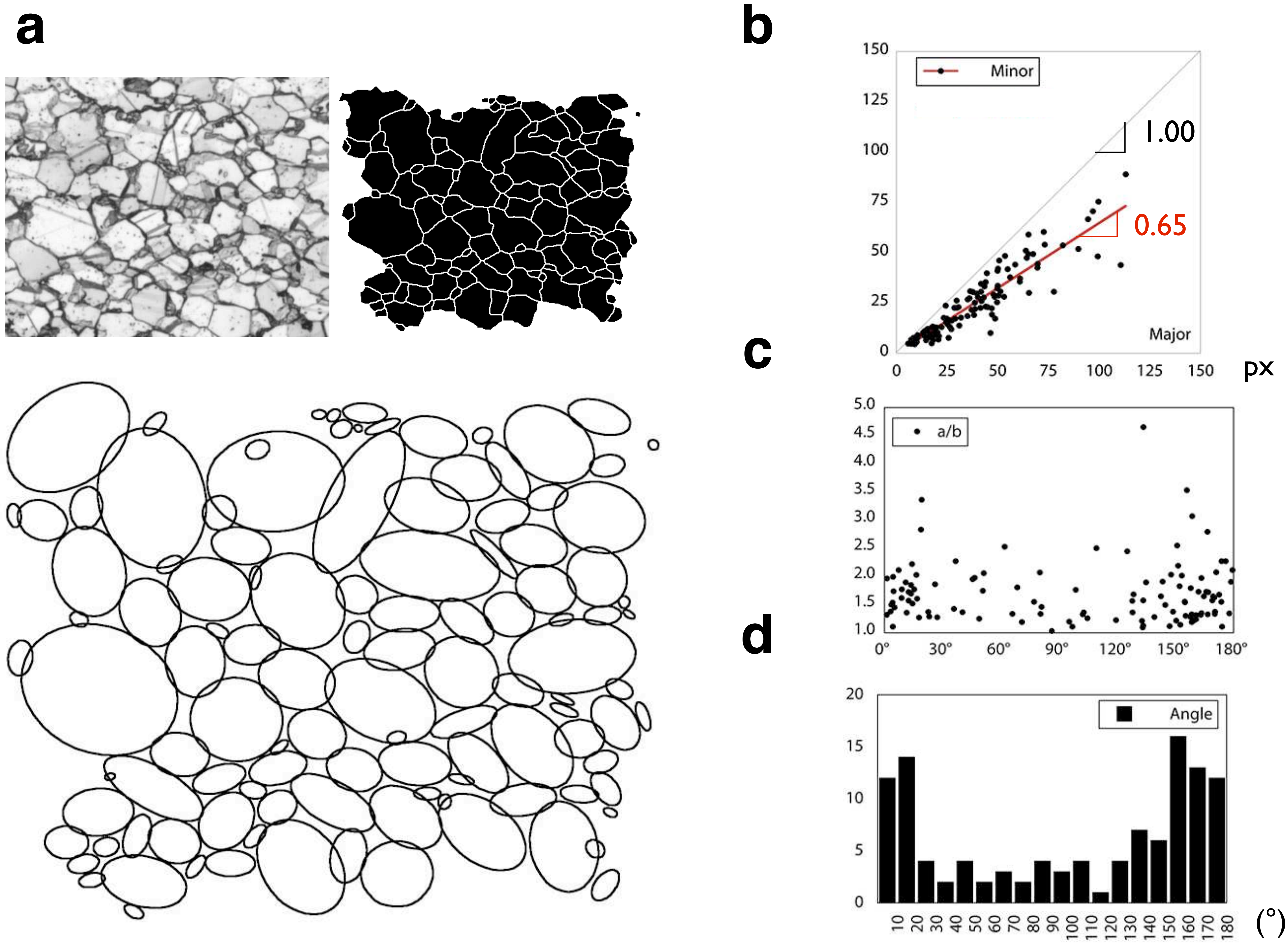

Figure 1.8
Image analysis using best-fit ellipses.
(a) Plot of best-fit ellipses to cross sectional areas of calcite grains (original image and grain map shown above);
(b) shape of ellipses: minor axis versus major axis; curve fit indicates axial ratio of 0.65; slope 1.00 for circle is also indicated;
(c) shape fabric: aspect ratio (= major axis / minor axis) versus orientation of major axis (corresponds to Rf-φ plot);
(d) preferred orientation: histogram of angles.

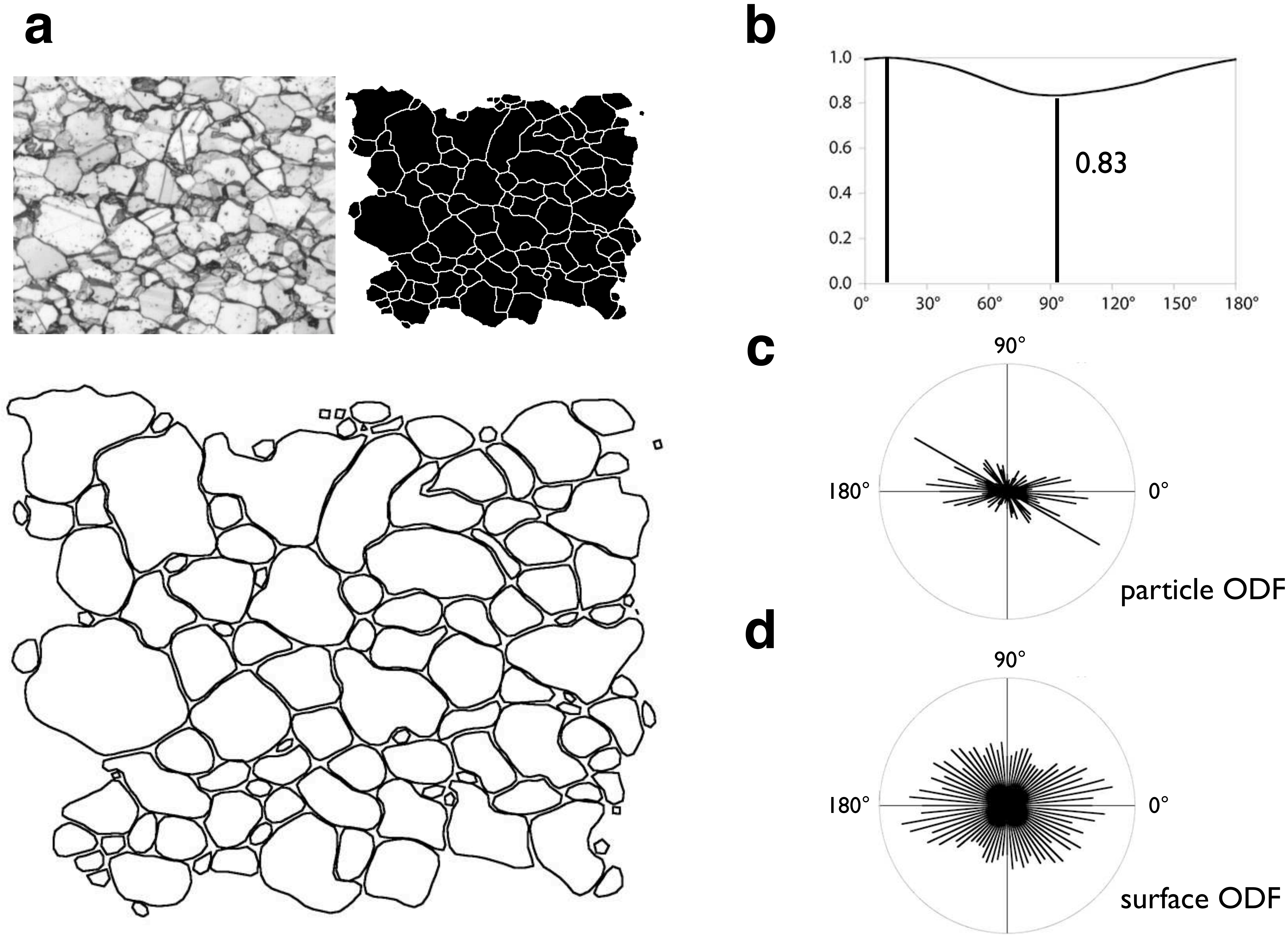

Figure 1.9
Image analysis using outlines.
(a) Plot of x-y coordinates of outlines (original image and grain map shown above);
(b) bulk shape fabric: projection function indicating bulk anisotropy (b/a = 0.83 and bulk preferred orientation (= 10°);
(c) particle fabric: orientation distribution function (ODF) of longest projection of grains;
(d) surface fabric: ODF of grain boundary outlines.

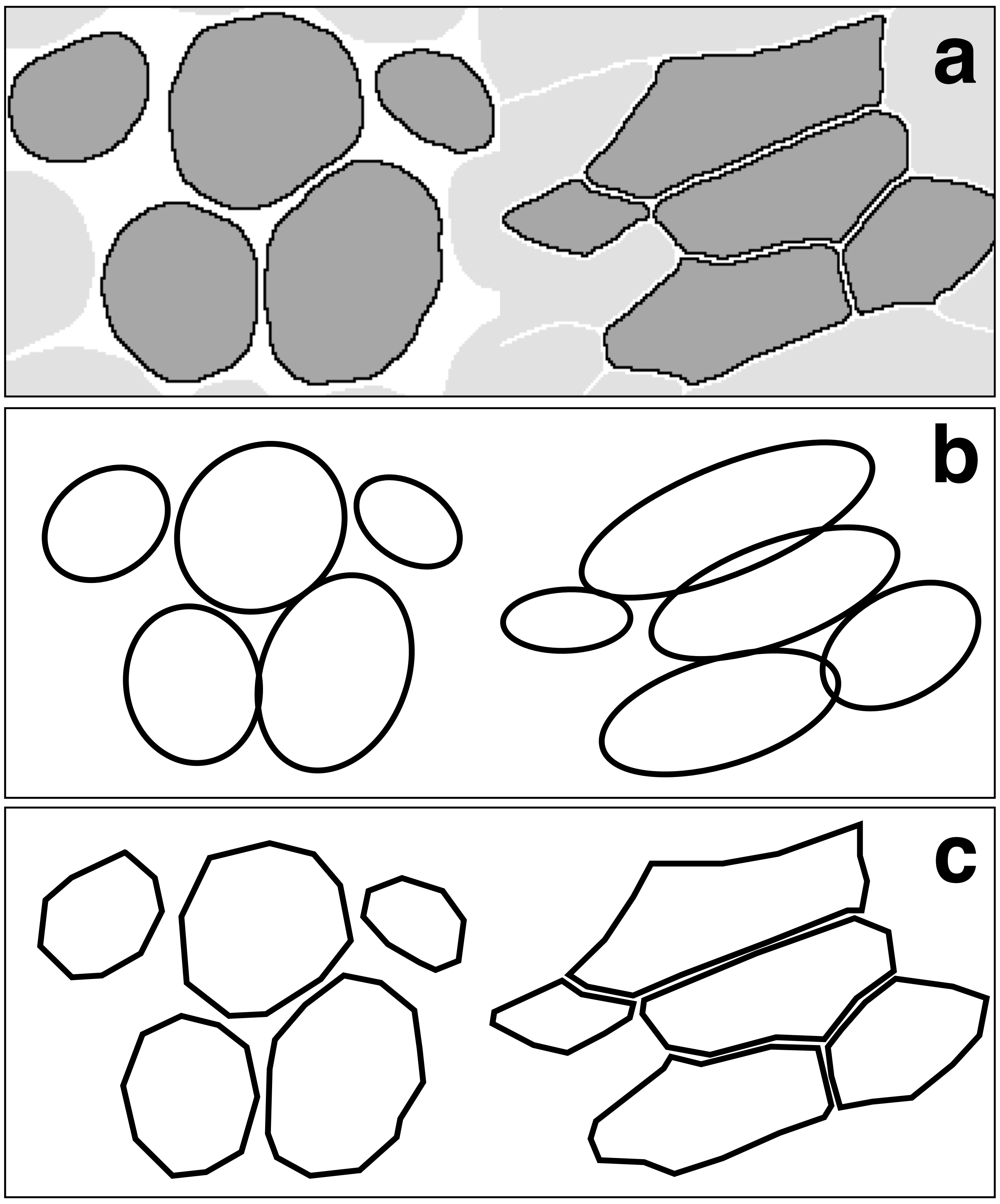

Figure 1.10
Segmentation.
(a) Segmented bitmaps of particles in matrix (left) and crystalline aggregates (right); five segments and segment boundaries are highlighted;
(b) approximation by best-fit ellipses;
(c) digitized outlines: approximation by polygonal chains.

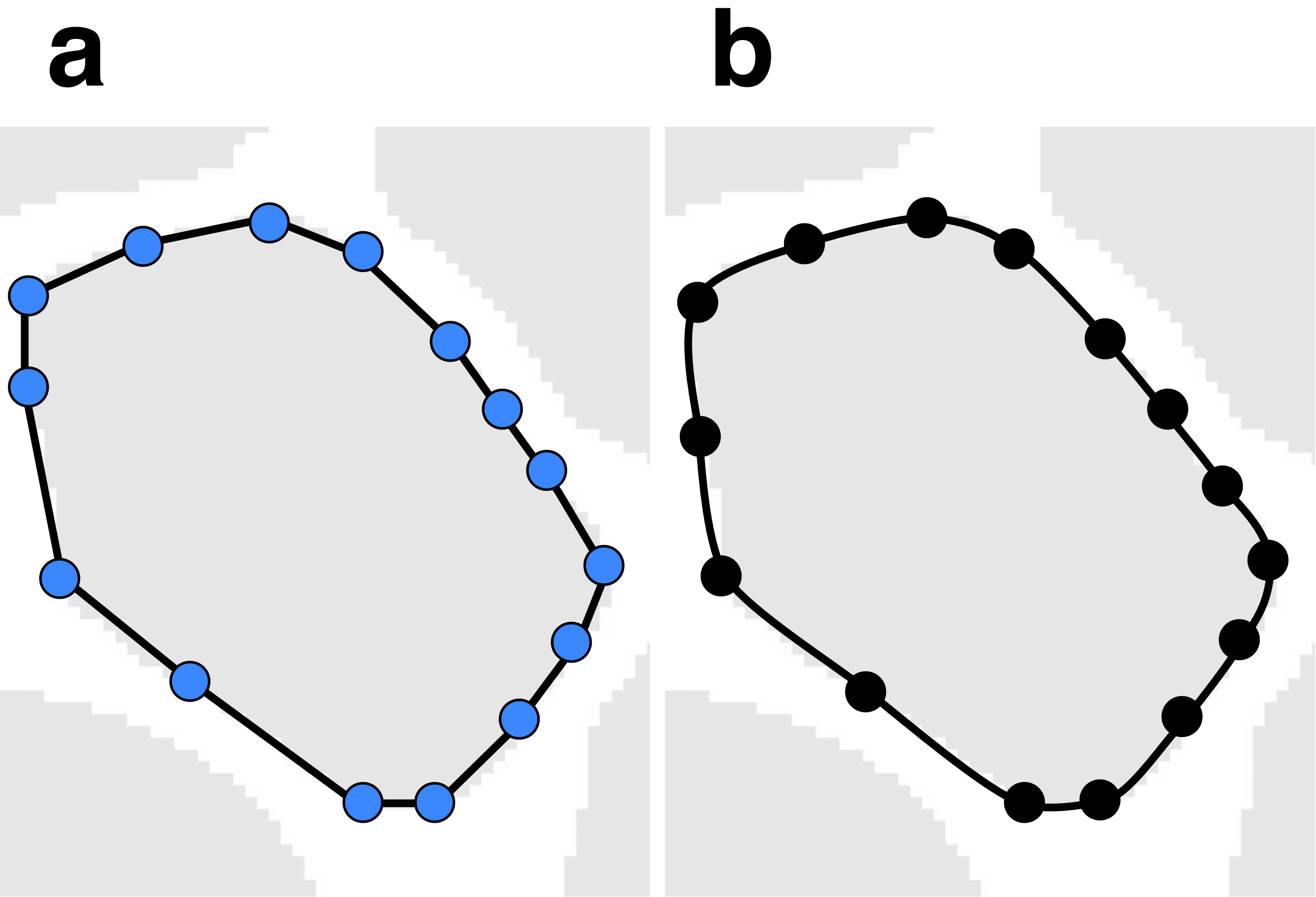

Figure 1.11
(a) Digitized outline connecting pixels (blue) along a segment boundary; note that the X-Y coordinates of the outline assume the same discrete (integer) values as the boundary pixels;
(b) the same segment after smoothing restoration: the x-y values of the vertices (black) now assume continuous values.

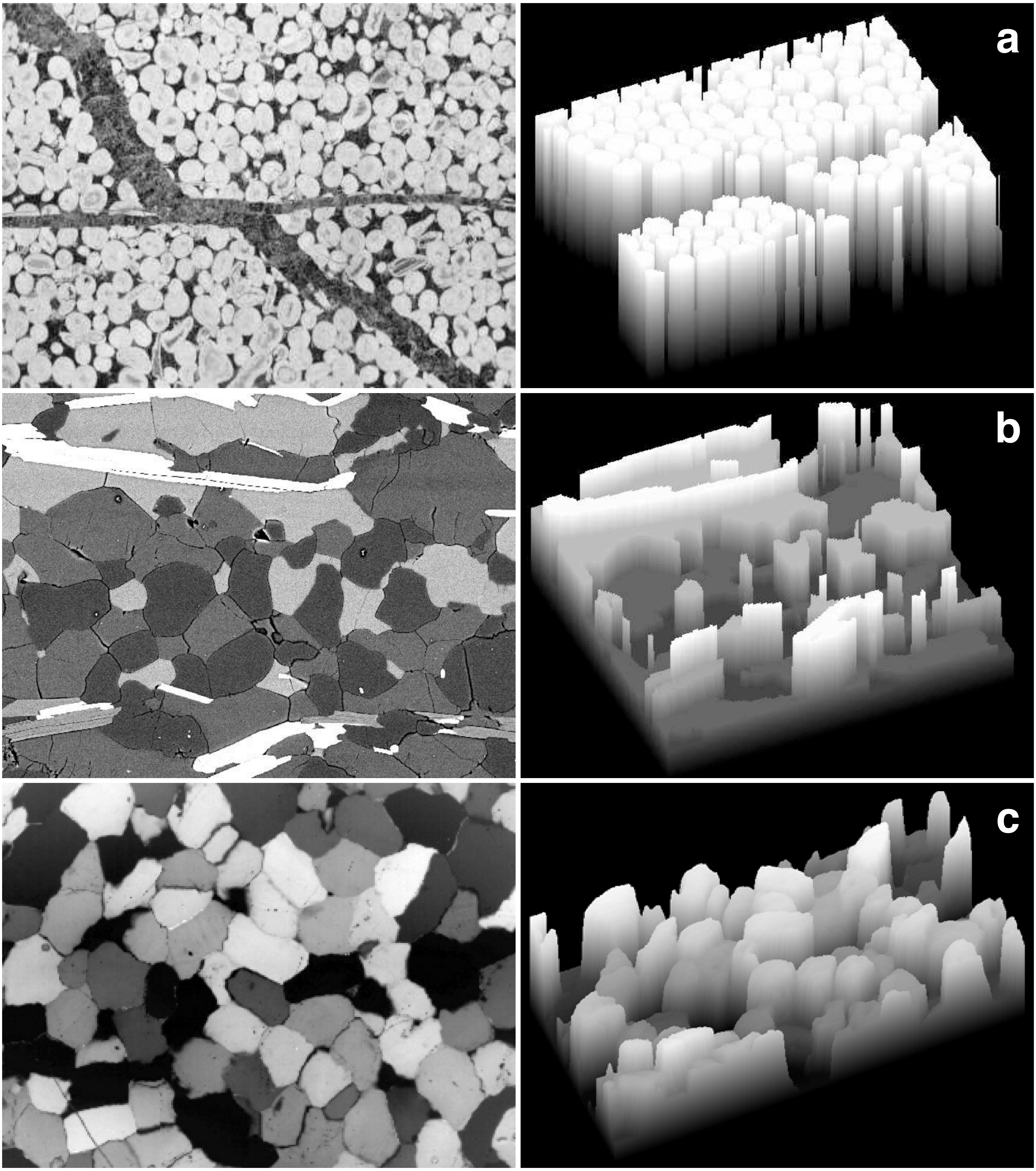

Figure 1.12
Image models.
Three original images (left) with 3-D topography of the corresponding image models (right).
(a) The image is essentially a bitmap: it shows two phases with two distinct gray levels: particles are white, the matrix is black;
(b) the image shows 5 discrete phases at five distinct gray levels;
(c) the image shows grains of one phase (quartz) at many gray levels (corresponding to different states of optical extinction).

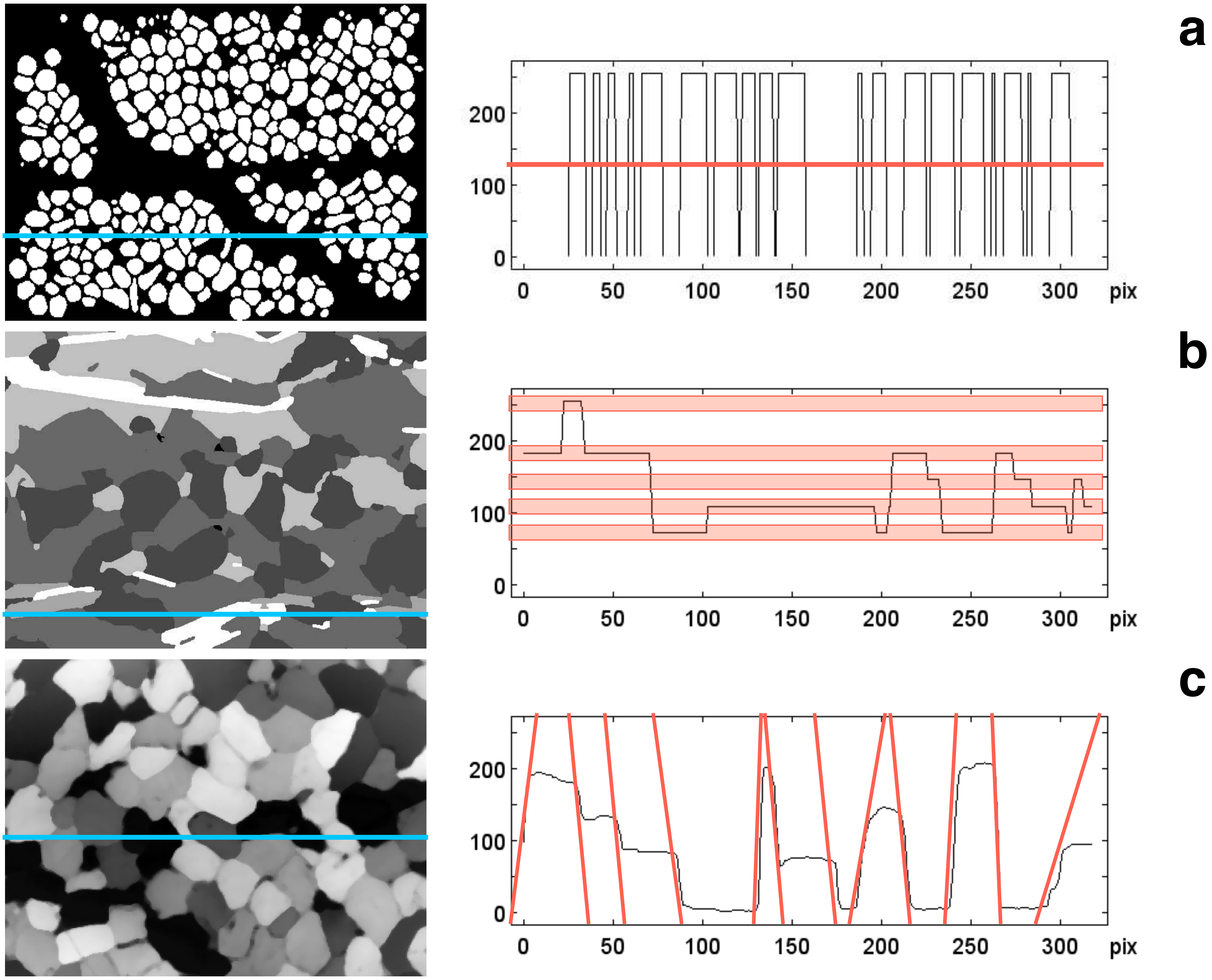

Figure 1.13
Segmentation based on image model.
Brightness representations of image models shown in Figure 1.12 (left) with profiles along blue traverses (right). The criteria for segmentation are superposed in red:
(a) thresholding: define a segment by a threshold gray value;
(b) gray level slicing: define a segment by a range of gray values, here five segments are created;
(c) edge detection: define a segment boundary by a steep gray value gradient.
Thresholding and gray level slicing are point operations (POP), edge detection is a neighborhood operation (NOP).