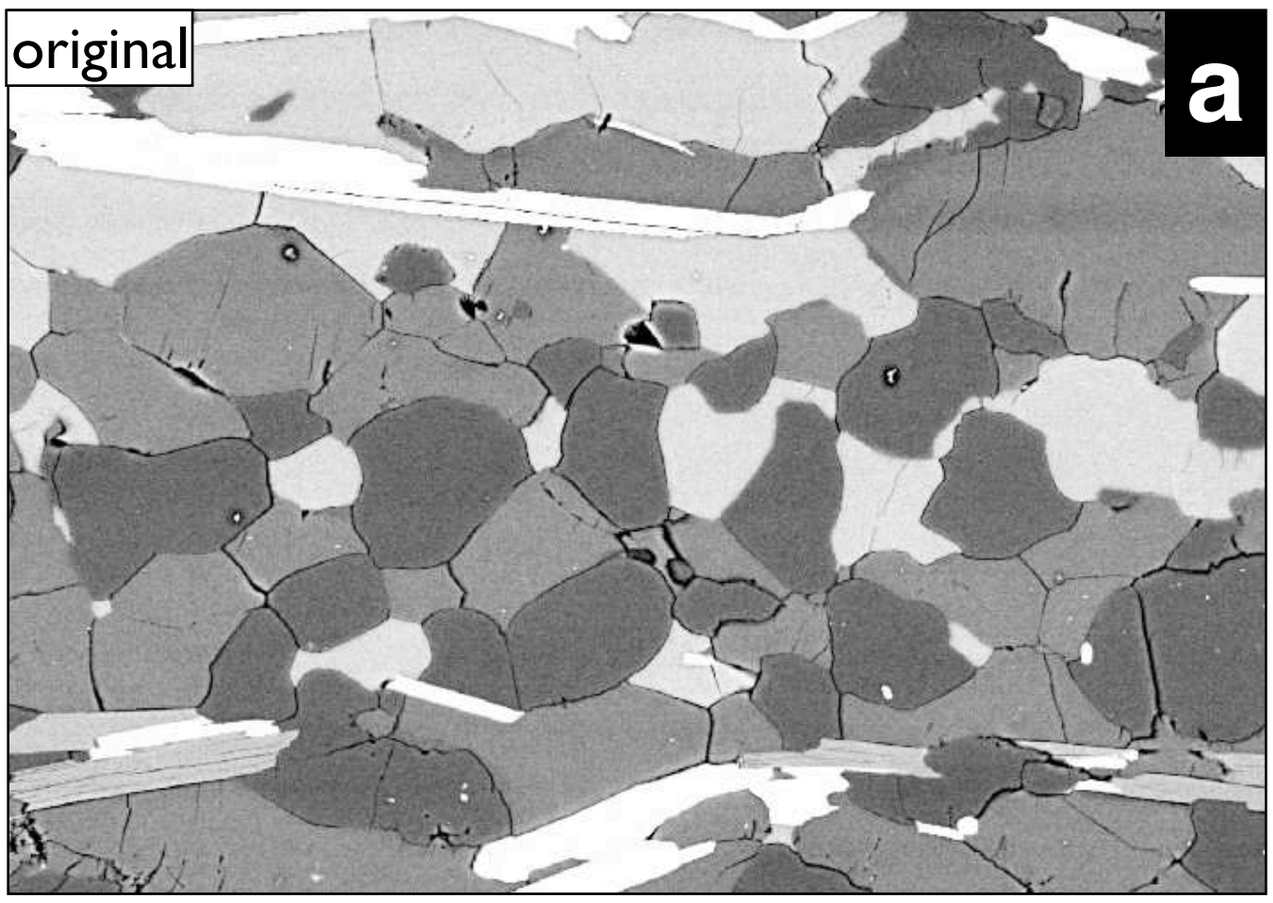
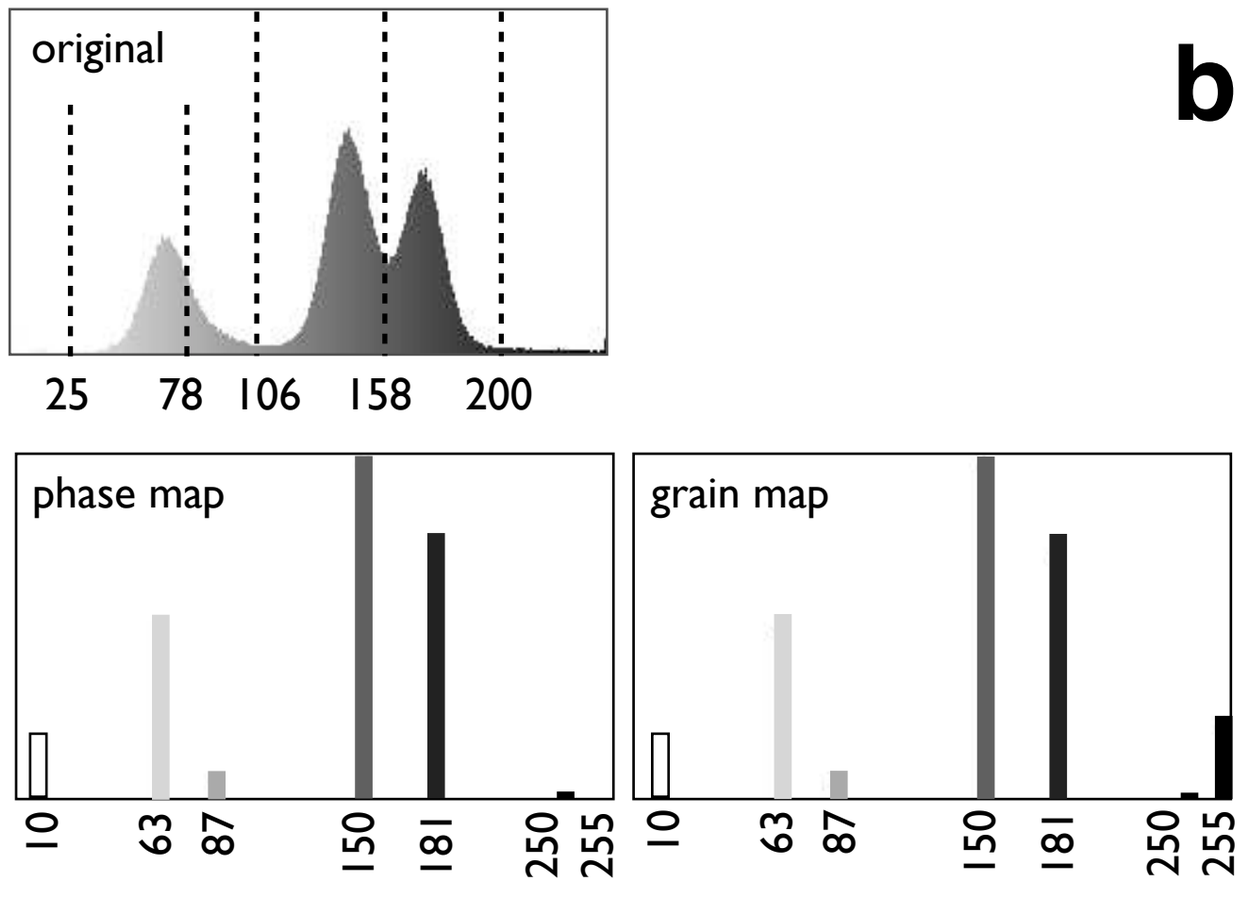
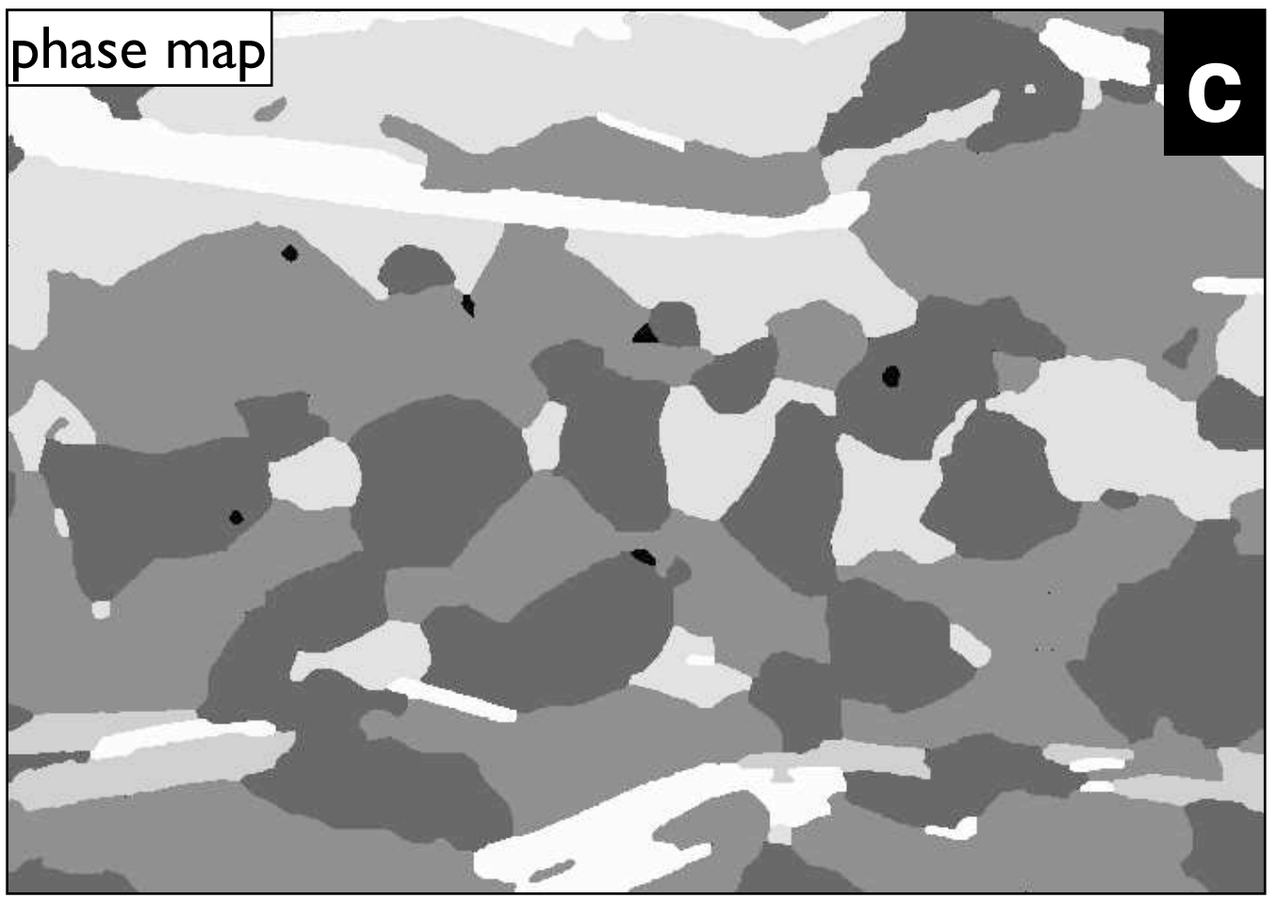






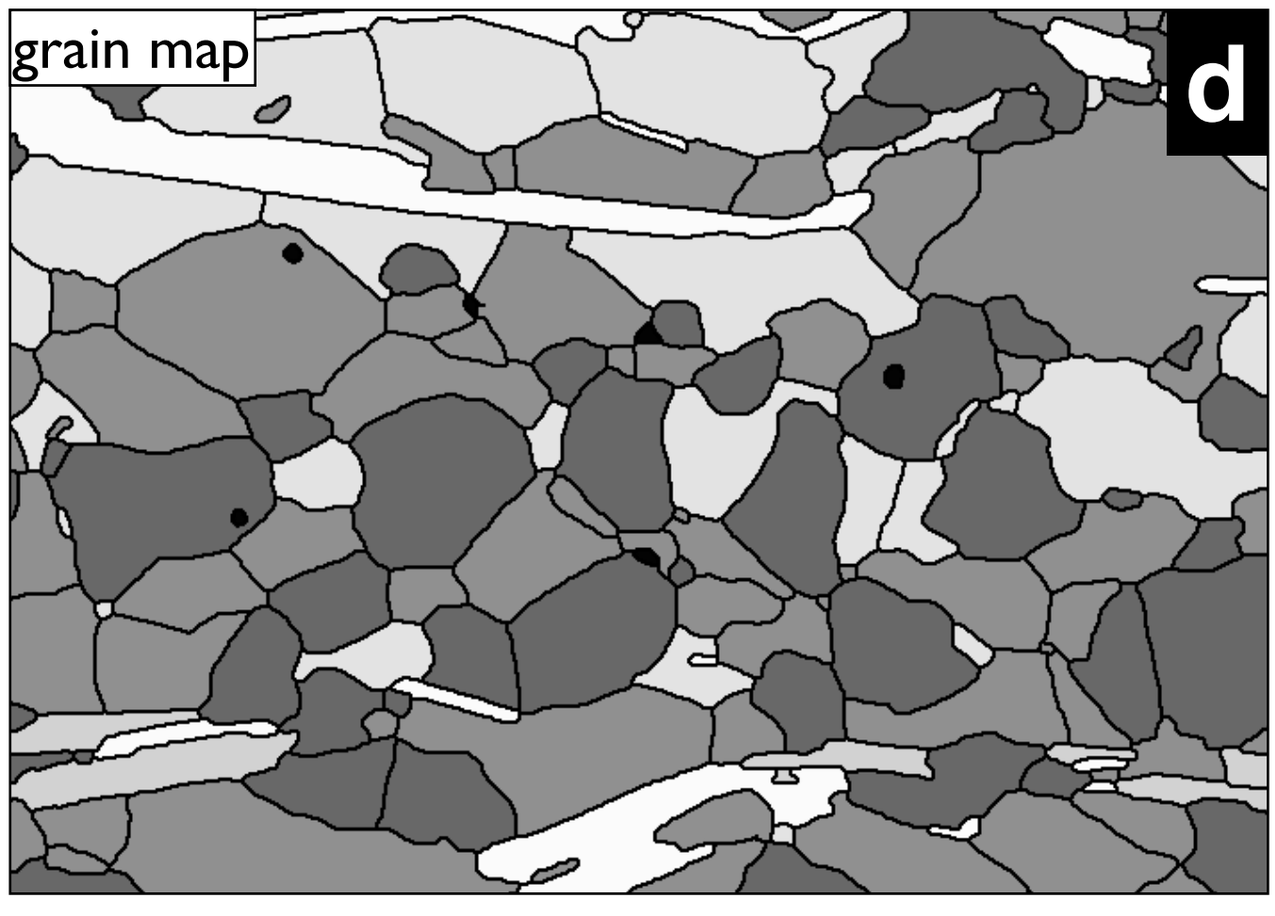


Figure 10.1
Micrograph and bitmaps of granitoid rock.
(a) Original image, SEM micrograph, BSE contrast;
(b) histograms of original (a) with limits between phases indicated, phase map (c) and grain map (d);
(c) phase map of (a);
(d) grain map of (a);
see Table 10.1 for gray values of minerals.

gray value in phase map	color	mineral	abbreviation
10	white	biotite	bio
63	very light grey	K- feldspar [1)]	kfs
87	light grey	muscovite	mu
150	medium grey	plagioclase	plg
181	dark grey	quartz	qtz
250	nearly black	unidentified [2)]	
255	black	grain boundaries [3)]	gb

Table 10.1
Gray values of five mineral phases in segmented image (Figure 10.1).
1) orthoclase; 2) mostly holes; includes grain and phase boundaries.

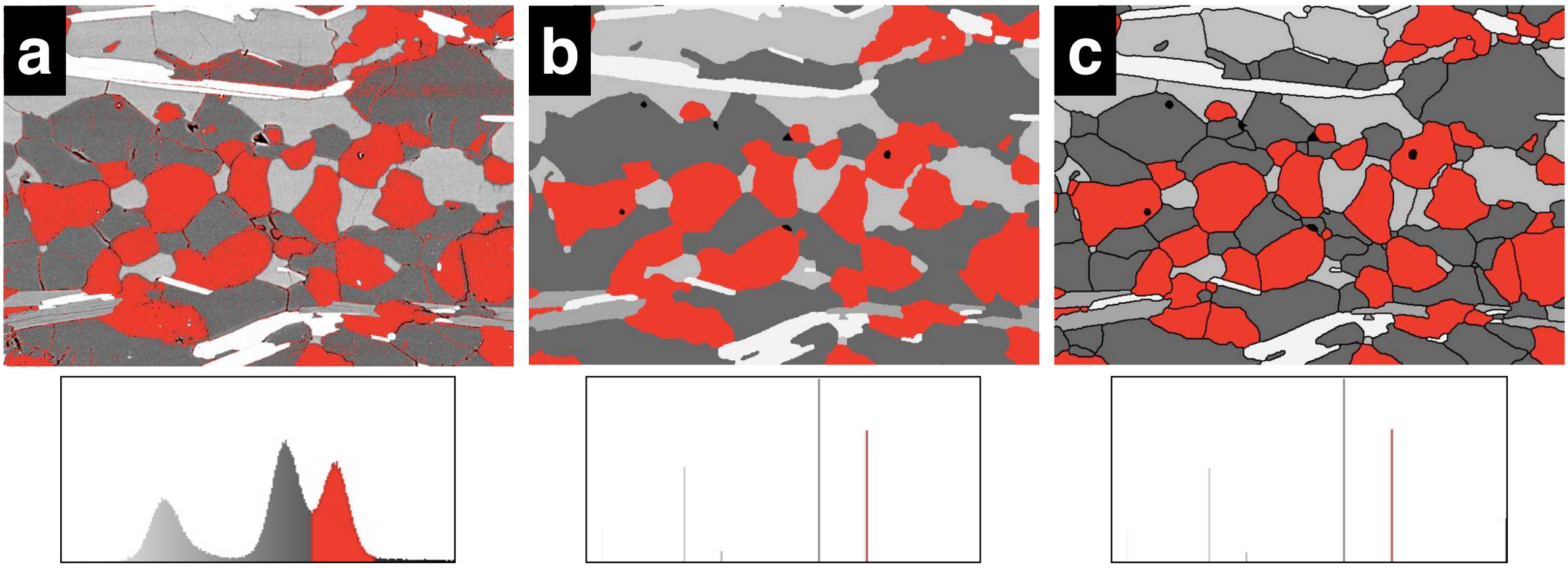


Figure 10.2
Measuring Density Slices.
Using the LUT tool, density slices are created for:
(a) the original SEM micrograph;
(b) the phase map;
(c) the grain map;
the range of gray values is set for quartz in all cases.

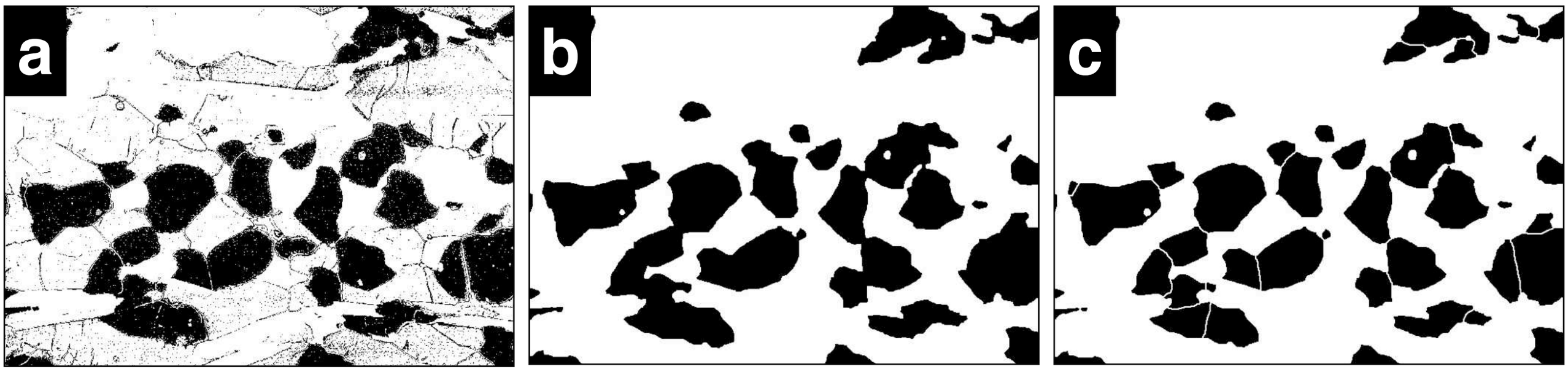
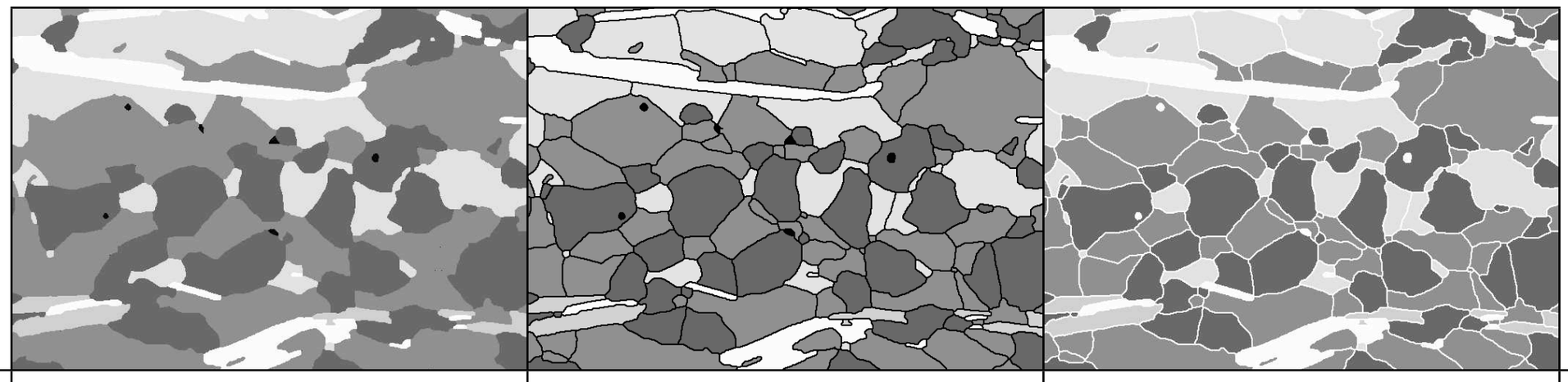


Figure 10.3
Measuring while Thresholding.
(a) Threshold (at GV=158) applied to original SEM micrograph; qtz+ indicates that quartz phase includes holes and grain boundaries;
(b) threshold (GV = 128) applied to bitmap of quartz phase;
(c) threshold (GV = 128) applied to bitmap of quartz grains.



phase	phase map 6 phases (%)	grain map 7 phases (%)	grain map 5 phases (%)	number of grains
biotite	7.72	6.61	7.25	15
K-feldspar	20.80	18.91	20.73	32
muscovite	2.41	2.03	2.23	7
plagioclase	40.11	36.86	40.41	66
quartz	28.83	26.79	29.38	47
rest	0.13	0.08		
grain boundaries		8.71		
sum	100.00	100.00	100.00	167

Table 10.2
Comparison of area evaluations.
6 phases = 5 mineral phases + 1 unidentified phase (holes, etc.);
7 phases = 5 mineral phases + 1 unidentified phase (holes, etc.) + grain boundary 'phase';
5 phases = 5 mineral phases only.

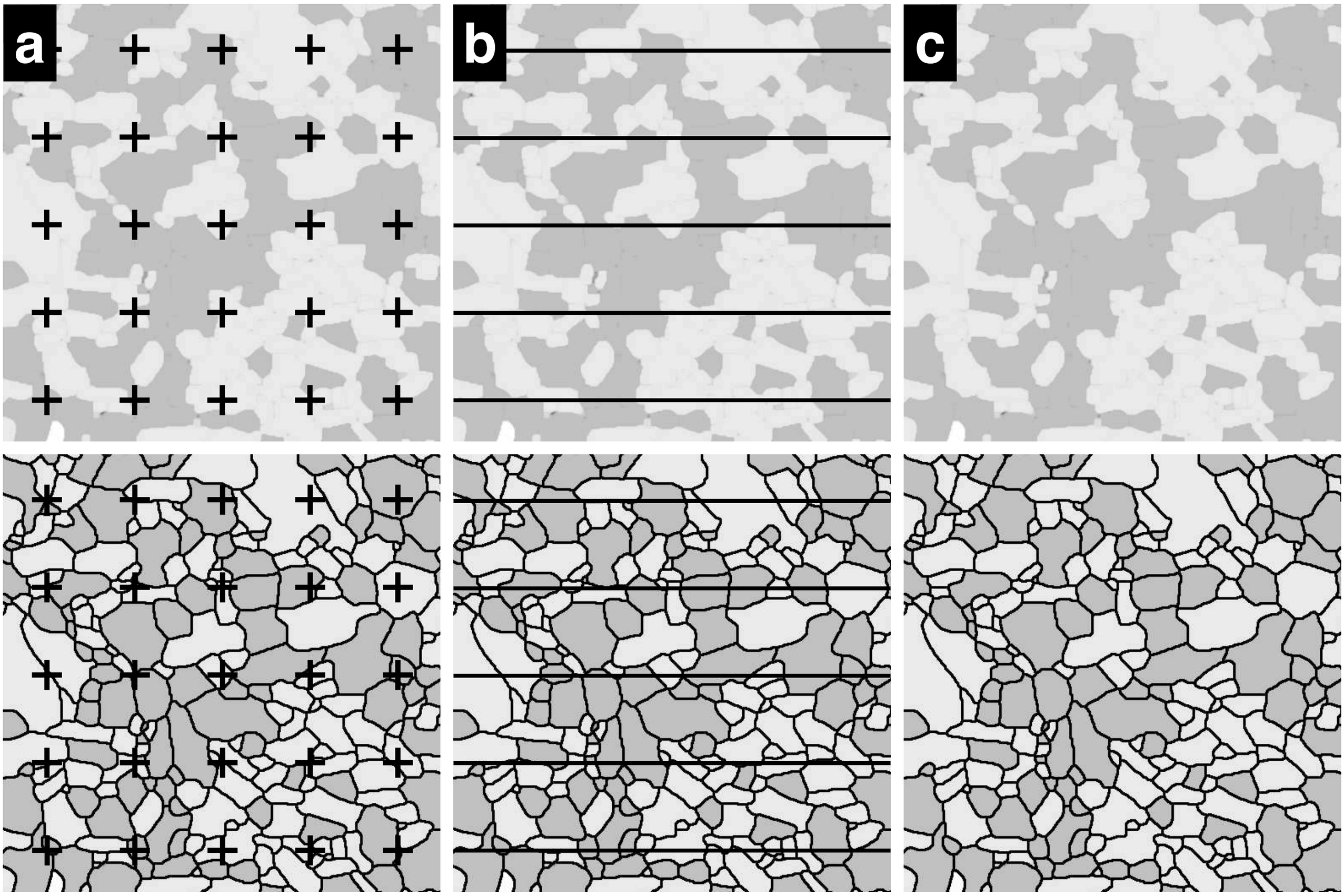


Figure 10.4
Determining area fractions.
Detail of a synthetic calcite (dark) - anhydrite (light) mixture is shown as phase map (top row) or as grain map with grain boundaries (bottom row).
(a) Using point fractions of a counting grid;
(b) using line fractions on test lines;
(c) counting the pixel on each of the phases.

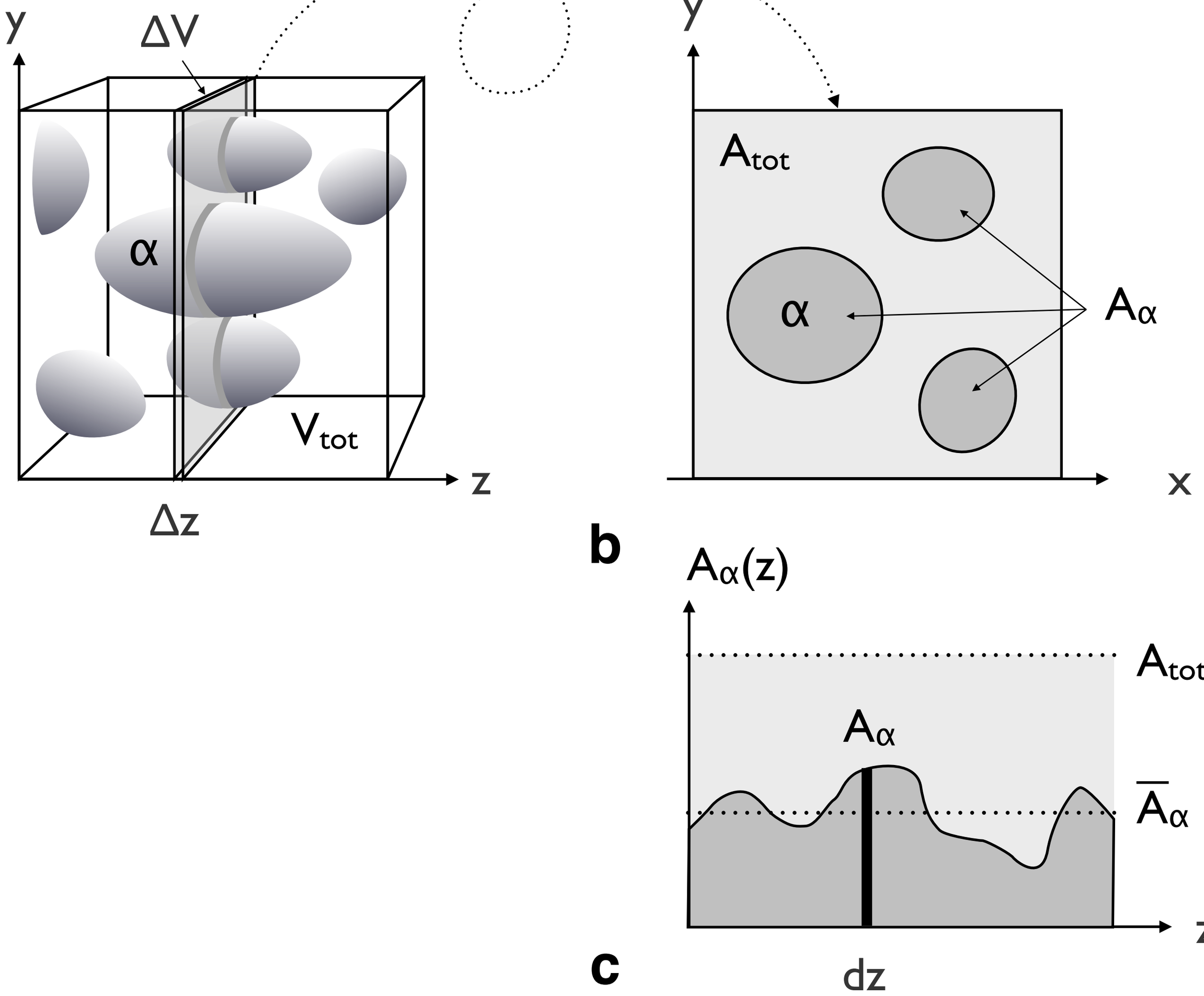
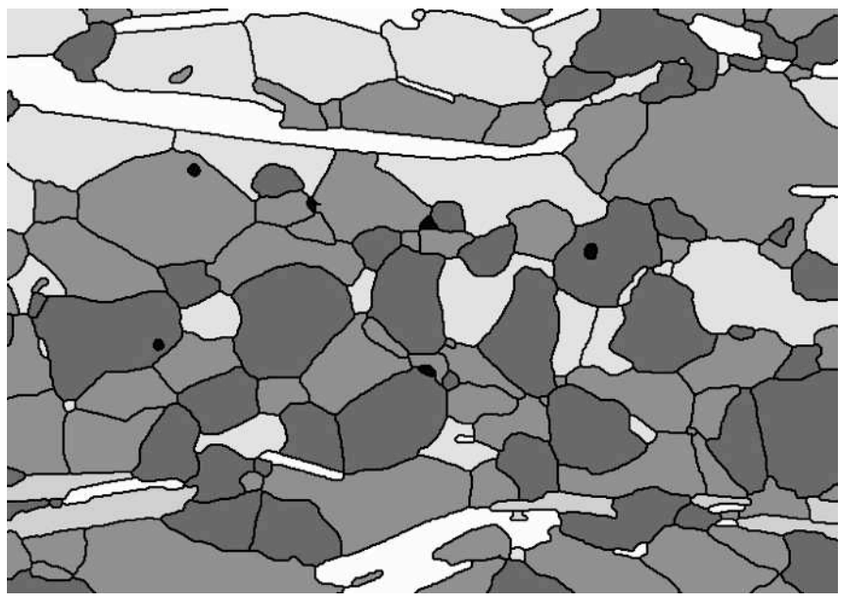


Figure 10.5
Volume fractions from area fractions.
(a) Schematic of a volume, V_{tot}, containing the phase α; the position of a section (thickness = Δz, volume = ΔV) is indicated;
(b) the x-y section shown in plane view; the total area of the image is A_{tot}; the fractional area of phase, A_α, is the sum of all the cross sectional areas of α;
(c) plot of A_α as a function of z; the total image area, A_{tot}, is constant; the fractional area, A_α, changes; the average area of α, $\bar{A}_\alpha$, is indicated; the black bar marks the position of the section shown in (b).

a

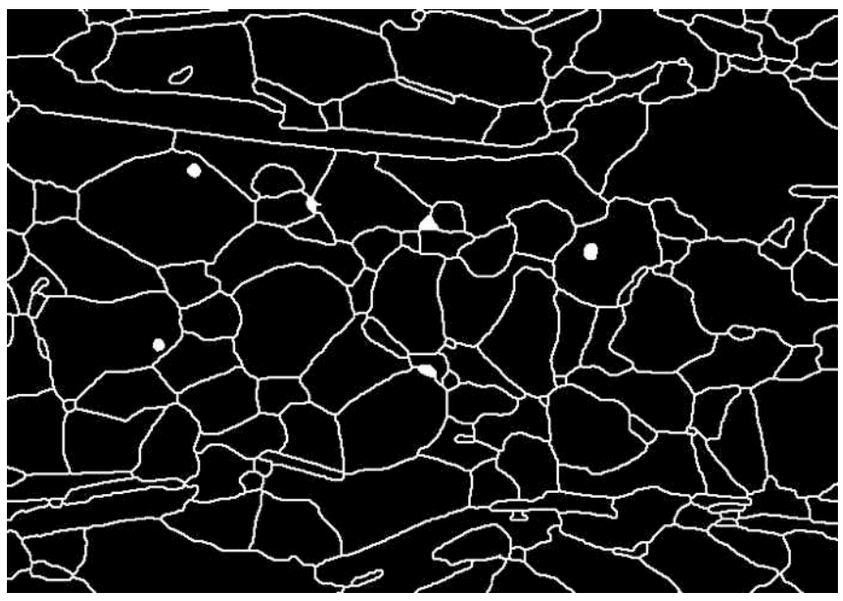


relative error = $1/\sqrt{N_{tot}}$

$1/\sqrt{N_{tot}} = 1/\sqrt{167} = 7.7\ \%$

⇒ quartz content: 29.4 % ± 2.3 %

b



N = 166
(incl. particles touching edges)

relative error = $\sqrt{((\sigma(a)/\bar{a})^2+1) / N_{tot}}$

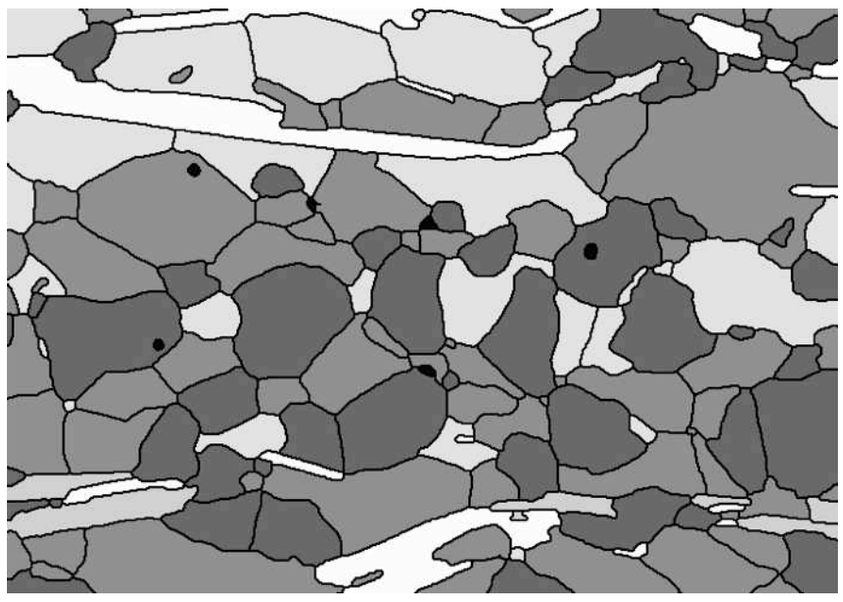
$\bar{a}$	=	1924 square pixel
$\sigma(a)$	=	2586 square pixel
$\sigma(a) / \bar{a}$	=	1.344
$(\sigma(a)/\bar{a}))^2 + 1$	=	$(1.344^2 + 1) = 2.806$

$\sqrt{((\sigma(a)/\bar{a})^2+1)/N} = \sqrt{(2.806/166)} = 13.0\ \%$

⇒ quartz content = 29.4 ± 3.8 %

Figure 10.6
Error estimates from the total number of grains.
Quartz content and error of estimate are calculated
(a) considering the total number of grains, N, only;
(b) considering the total number of grains, N, and the relative size variation, $\sigma(a)/\bar{a}$, of the cross sectional areas of all grains.

a

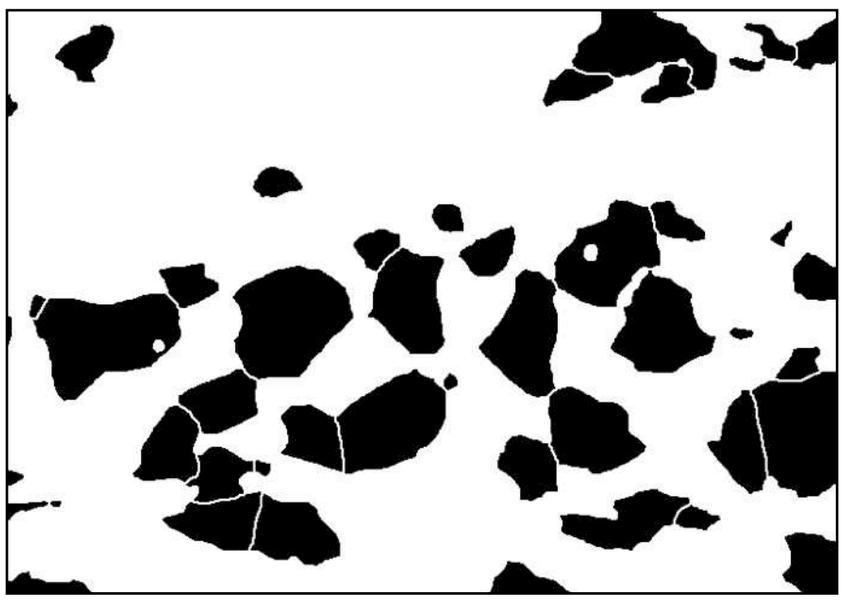


relative error = $1/\sqrt{N_\alpha}$

$1/\sqrt{N_\alpha} = 1/\sqrt{(47)} = 14.6\ \%$

⇒ quartz content: 29.4 % ± 4.3 %

b



$N_\alpha = 47$
(incl. particles touching edges)

relative error = $\sqrt{((\sigma(a)/\bar{a})^2+1) / N_\alpha)}$

$\bar{a}$	=	1996 square pixel
$\sigma(a)$	=	1999 square pixel
$\sigma(a) / \bar{a}$	=	1.002
$(\sigma(a)/\bar{a}))^2 + 1$	=	$(1.002^2 + 1) = 2.003$

$\sqrt{((\sigma(a)/\bar{a})^2+1)/N)} = \sqrt{(2.003/47)} = 20.6\ \%$

⇒ quartz content = 29.4 % ± 6.1 %

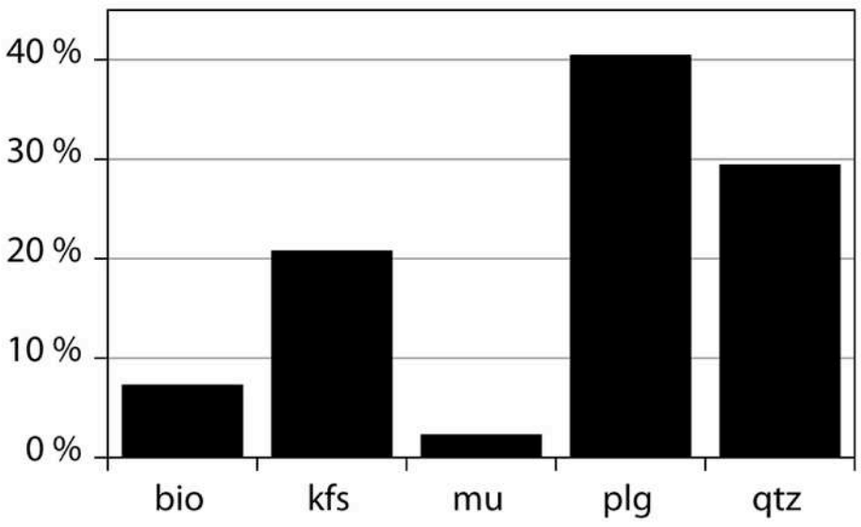
Figure 10.7
Error estimates from the number of quartz grains.
Quartz content and error of estimate are calculated
(a) considering the number of quartz grains, N_α, only;
(b) considering the number of quartz grains, N_α, and the relative size variation, $\sigma(a)/\bar{a}$, of the cross sectional areas of the quartz grains.

phase	area (%)	#	relative error $1/\sqrt{N}$	1 ±(%)	2 ±(%)	3 ±(%)	4 ±(%)
biotite	7.25	15	0.258	0.56	0.94	1.87	4.00
K- feldspar	20.73	32	0.177	1.60	2.70	3.67	5.82
muscovite	2.23	7	0.378	0.17	0.29	0.84	1.21
plagioclase	40.41	66	0.123	3.13	5.25	4.97	9.11
quartz	29.38	47	0.146	2.27	3.82	4.29	6.06
all	100.00	167	0.0774	7.74	13.00	7.74	12.96

1 using relative error and $N=N_{tot}$
2 using area variation and $N=N_{tot}$
3 using relative error and $N=N_{phase}$
4 using area variation and $N=N_{phase}$

Table 10.3
Estimates and relative errors (in %) of mineral composition of granitoid rock.
1 using relative error and $N=N_{tot}$
2 using area variation and $N=N_{tot}$
3 using relative error and $N=N_{phase}$
4 using area variation and $N=N_{phase}$

a



kfs : plg : qtz =
0.23 : 0.45 : 0.32

b

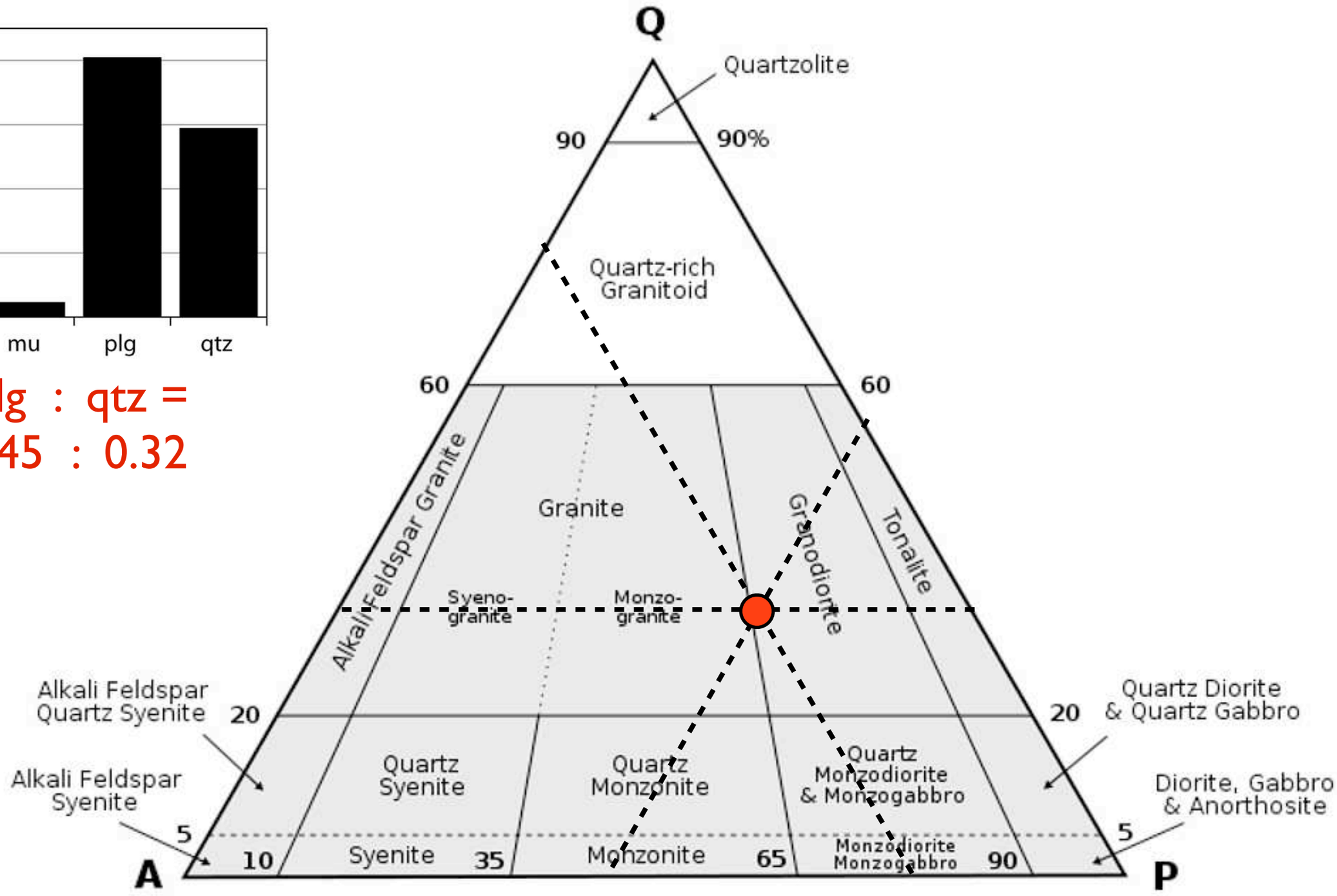
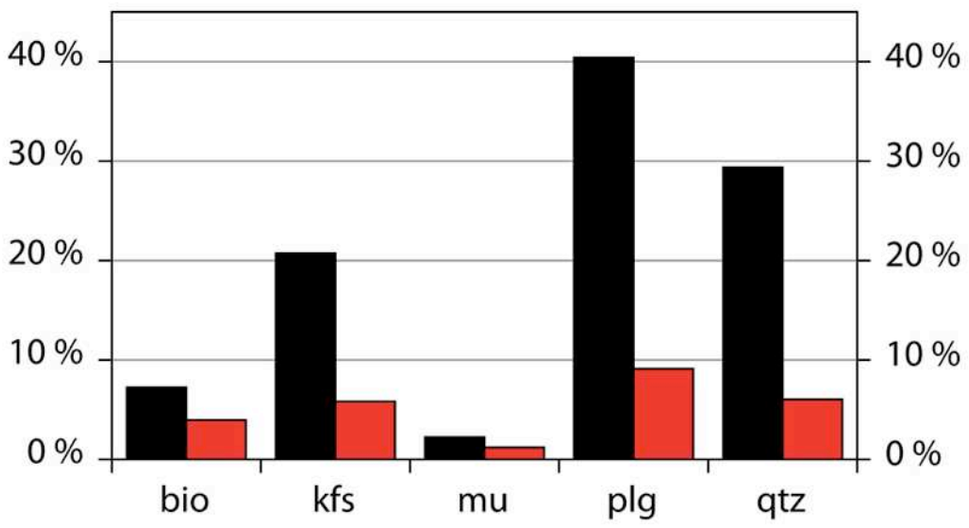


Figure 10.8
Determination of rock type from modal composition.
(a) Histogram showing the calculated volume fractions for 5 mineral phases, the ratio (K-feldspar : plagioclase : quartz) is indicated below;
(b) QAP diagram with composition of analyzed sample: granodiorite.

a



K-feldspar	20.8 % ± 5.8 %
plagioclase	40.1 % ± 9.1 %
quartz	28.8 % ± 6.1 %

b

Figure 10.9
Determination of rock type from modal composition.
(a) Histogram showing the calculated volume fractions (black) and errors (red) for 5 mineral phases, the number for K-feldspar, plagioclase and quartz are indicated below;
(b) QAP diagram with composition of analyzed sample, including a circle outlining the maximum error (9.1 %): granodiorite or monzogranite.

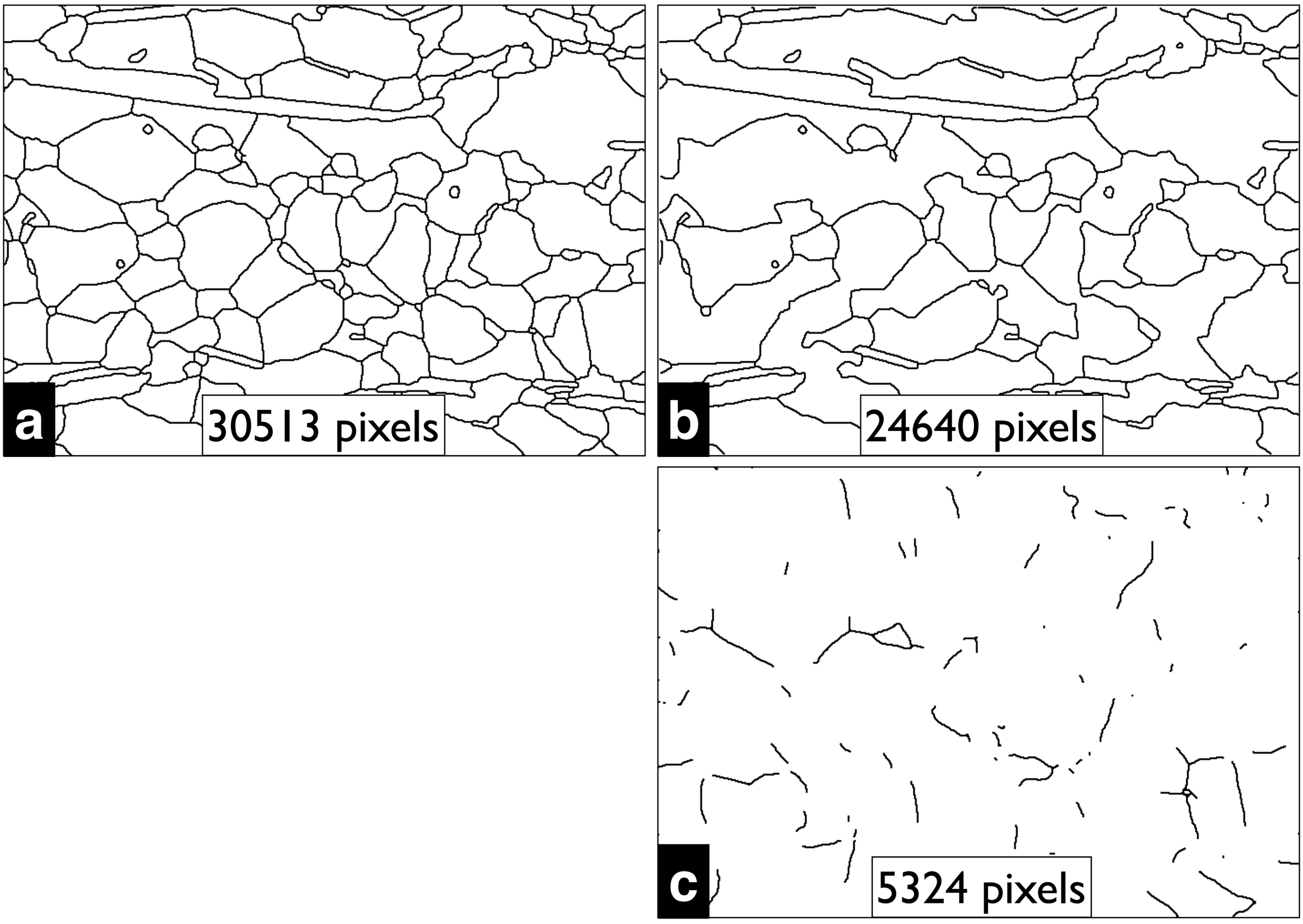


Figure 10.10
Surfaces as volumes.
Fractional area of 'grain boundary volume' is given as pixel count.
(a) Grain boundaries including phase boundaries;
(b) phase boundaries only;
(c) grain boundaries, sensu strictu;
the number of pixels of the boundary 'phase' is indicated for each.

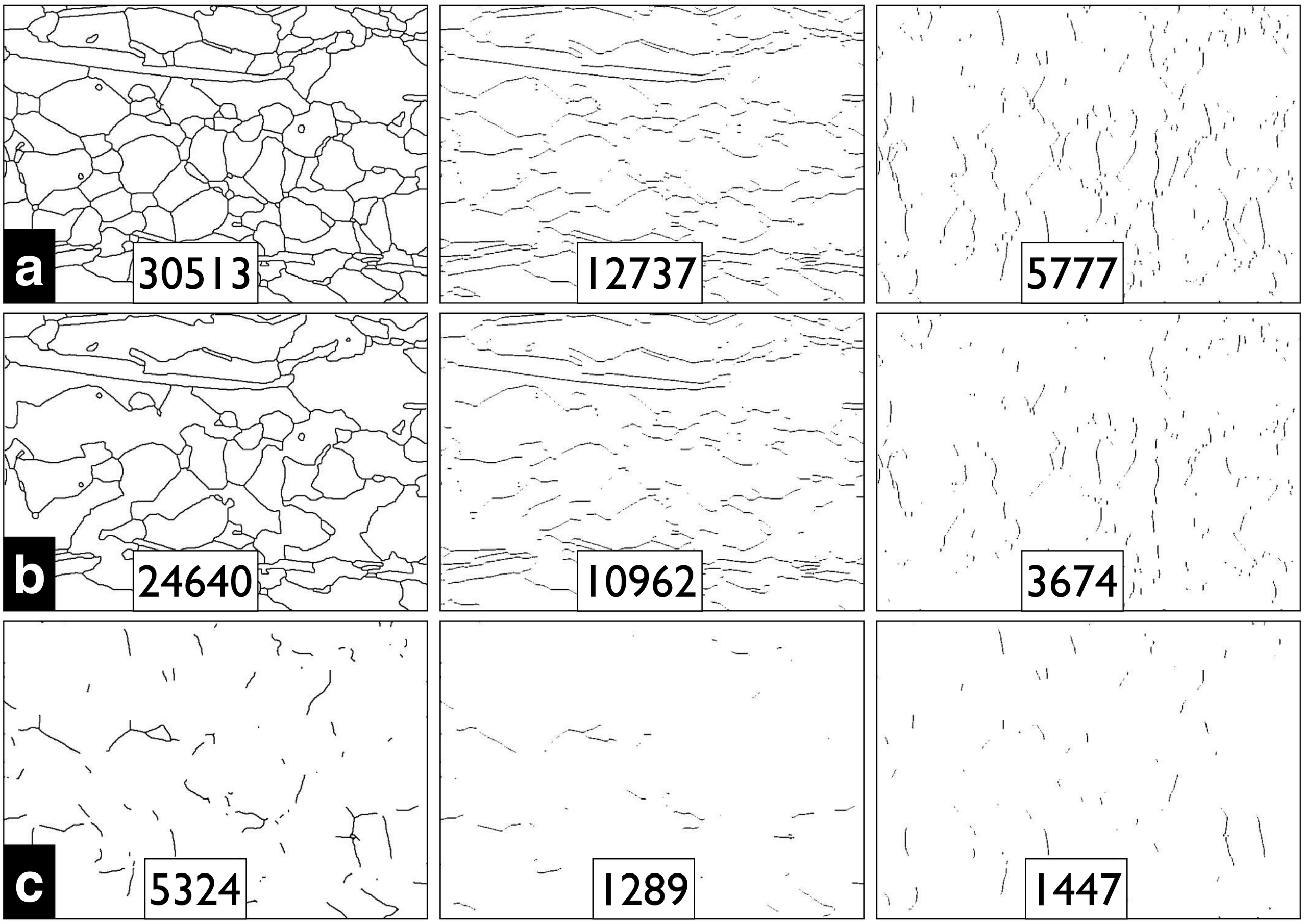


Figure 10.11
Horizontal and vertical fractions of boundaries.
From left to right, the complete boundaries, the horizontal and the vertical fractions are shown.
(a) Grain boundaries including phase boundaries;
(b) phase boundaries only;
(c) grain boundaries, sensu strictu;
the number of pixels of the boundary 'phase' is indicated for each.