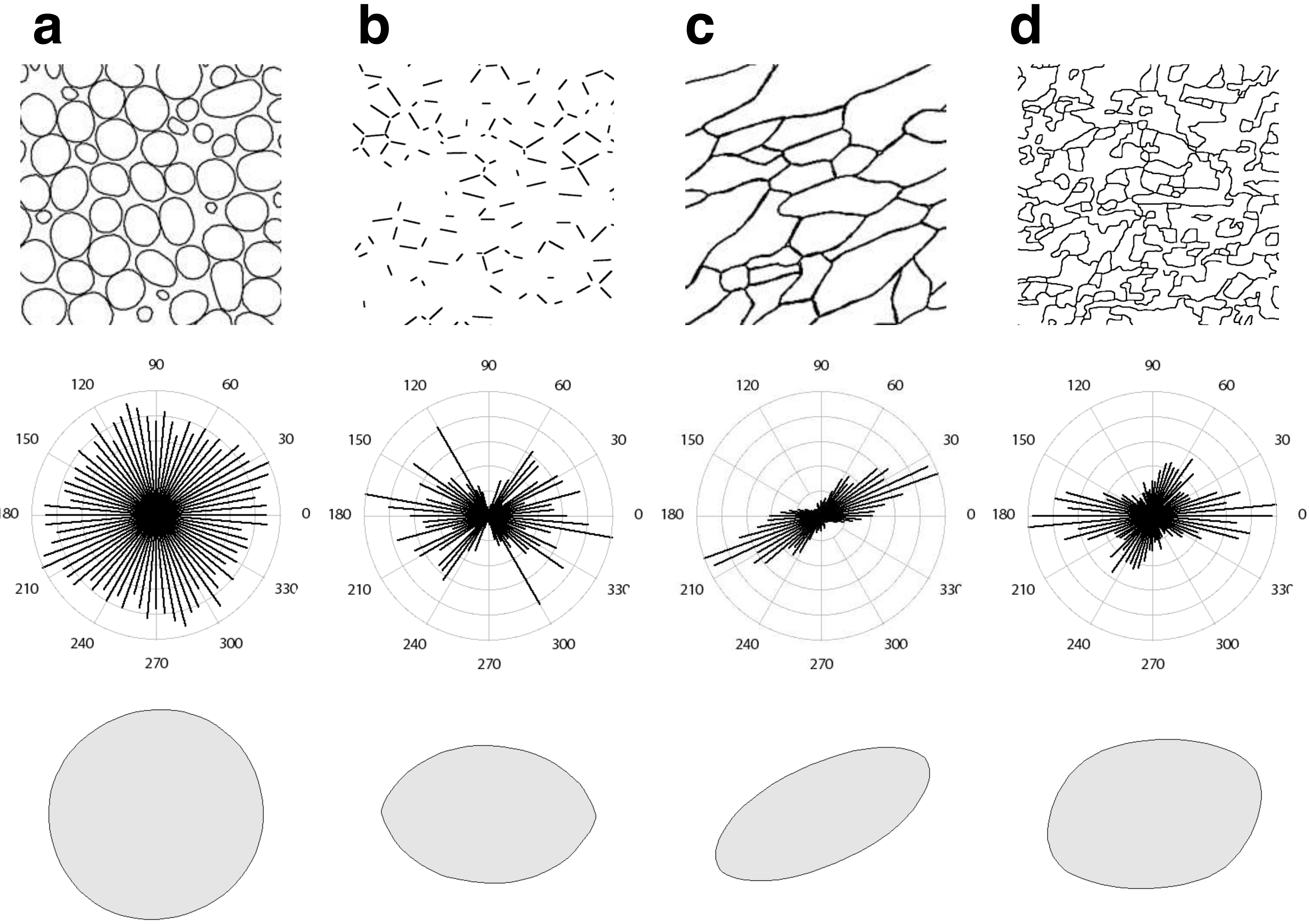

Figure 16.1
Geometric anisotropy - physical processes.
From top to bottom: Bitmap, rose diagram (ODF of line segments) and characteristic shape of four different microstructures are shown (for method, see previous chapter).
(a) Orientation of ooides in oolithic limestone caused by depositional processes (cross bedding);
(b) pressure solution contacts caused by vertical compaction (gravity);
(c) elongation of calcite grains (sample CT1, experimentally sheared at 600°C) caused by homogeneous deformation of marble (strain);
(d) lobate grain boundaries of calcite grains (sample CT4, experimentally sheared at 900°C) caused by grain boundary migration.

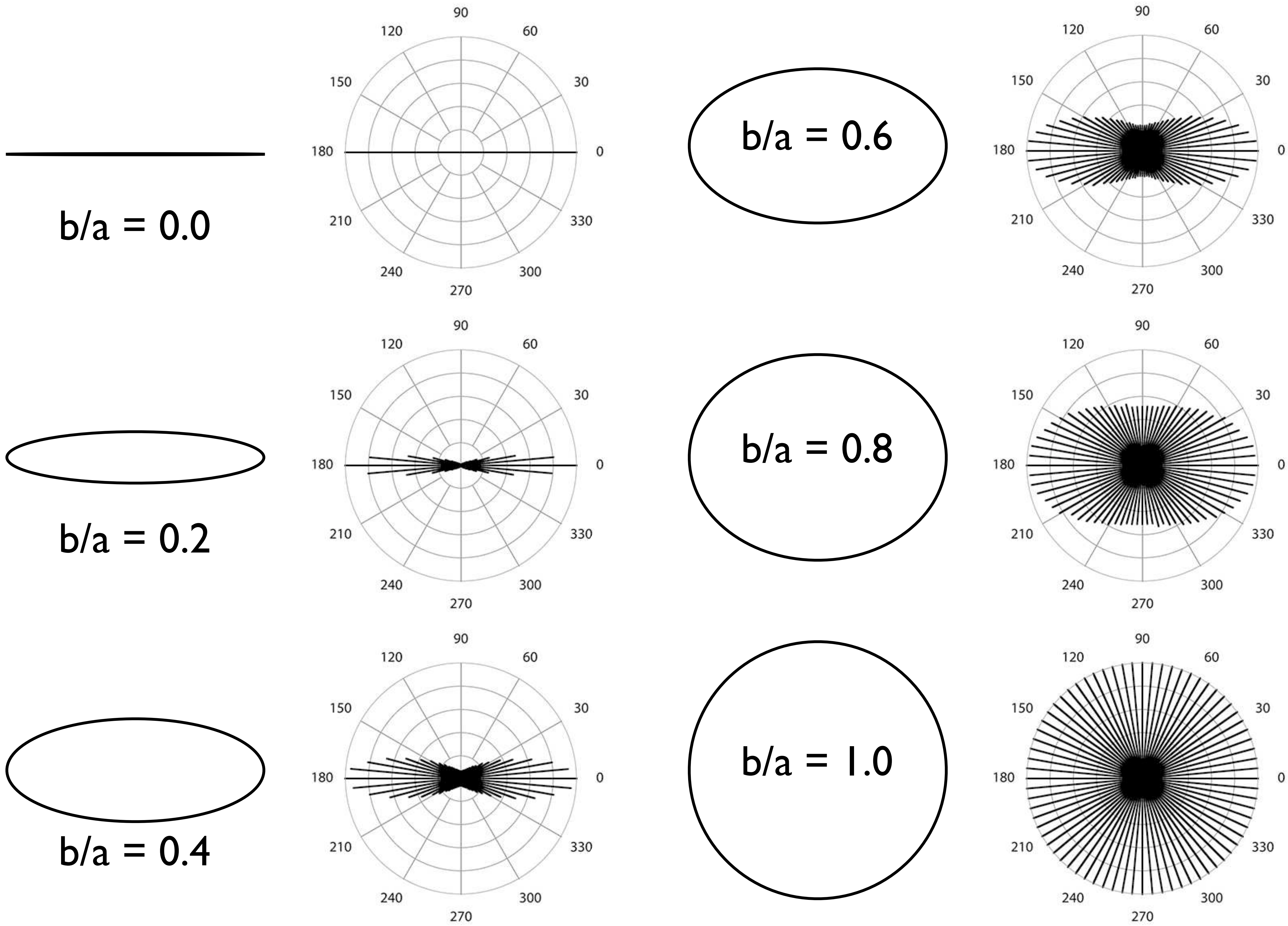

Figure 16.2
Orientation distribution functions of elliptical outlines.
Ellipses with various axial ratios, b/a, and rose diagram of corresponding ODF of line segments are shown.

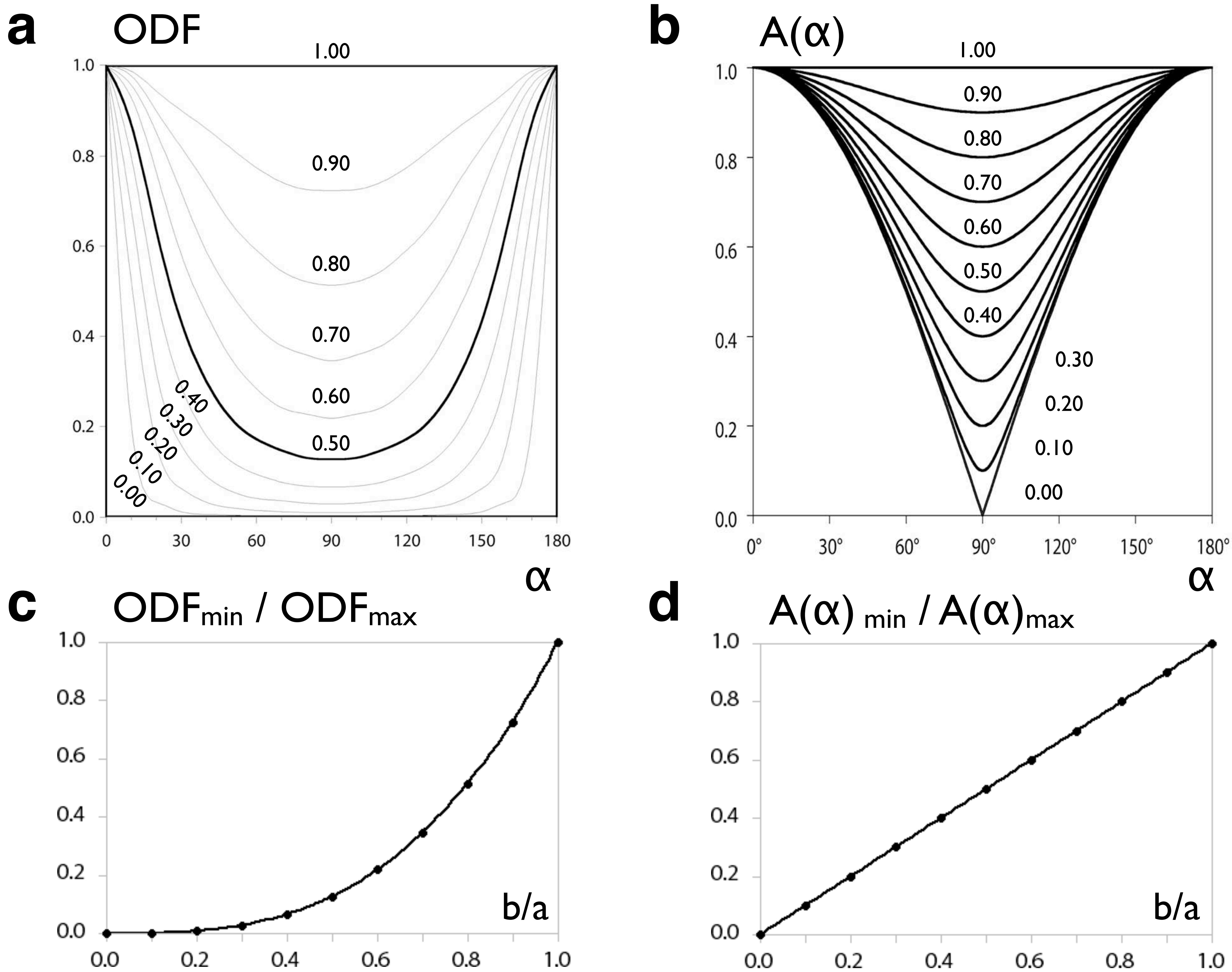

Figure 16.3
ODF versus projection curve of elliptical outlines.
(a) ODF of lines segments ($\Sigma L(\alpha)$) of elliptical outlines shown as orthogonal plot; axial ratios of ellipses are indicated;
(b) projection curves of ellipses with varying axial ratios;
(c) ratio between ODF_{min}/ODF_{max} and b/a of ellipse;
(d) ratio between $A(\alpha)_{min}/A(\alpha)_{max}$ and b/a of ellipse.

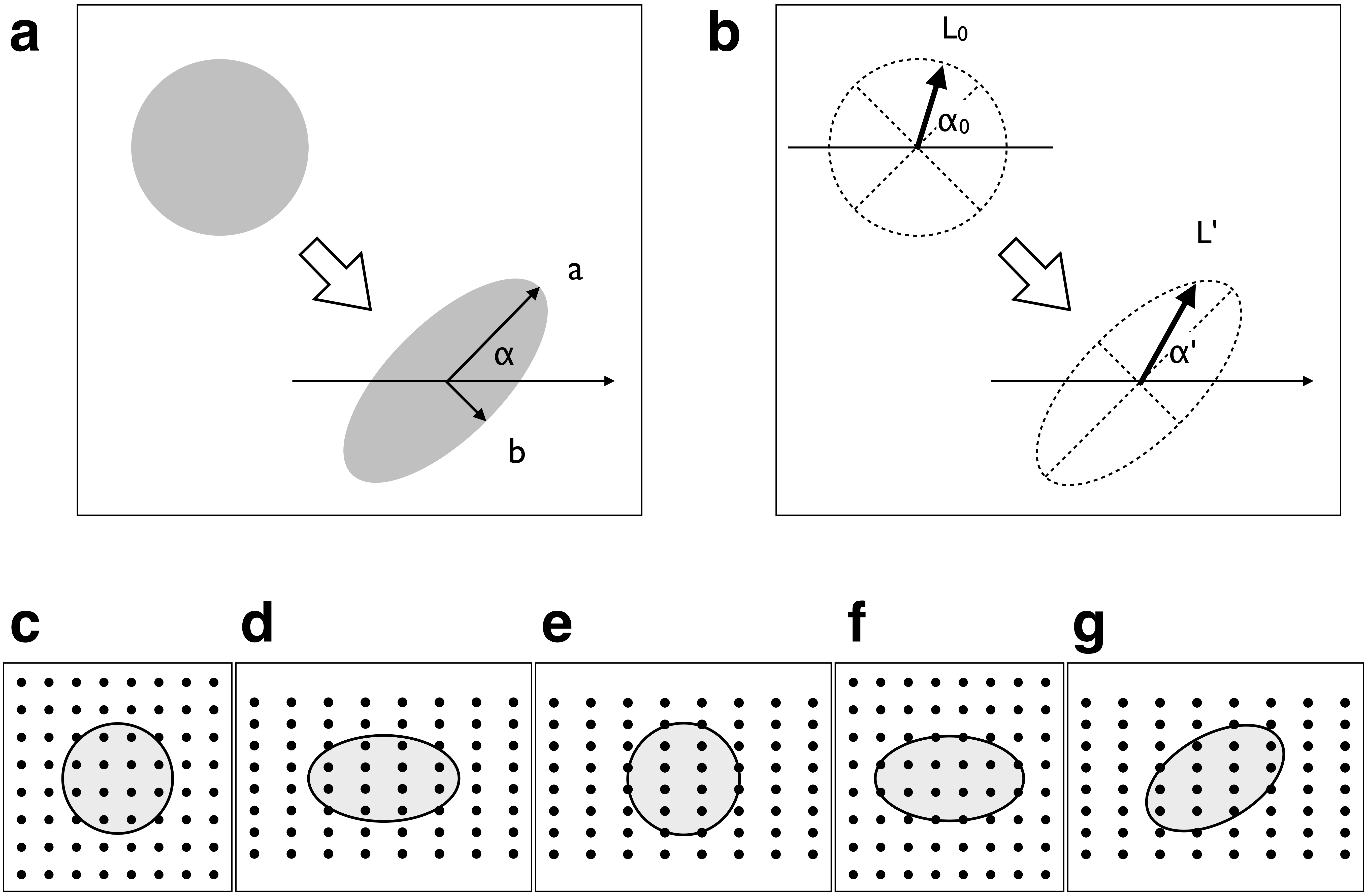

Figure 16.4
Strain ellipse and strain marker.
(a) Circle is deformed homogeneously; radius of circle = 1.00, a = long axis, b = short axis of strain ellipse; α = orientation of (long axis of) strain ellipse; if deformation is area conserving: $\pi r^2 = \pi ab$;
(b) line segment is deformed; L_0 = original lenght; L' = deformed length; α_0 = original orientation; α' = orientation after deformation; elongation $\varepsilon = (L' - L_0) / L_0$;
(c) unit circle superposed on starting material with material points;
(d) deformation of material (c): unit circle deforms with material = strain marker; ellipse = strain ellipse;
(e) deformation of material (c): unit circle does not deform with material ≠ strain marker;
(f) no deformation of material (c): unit circle deforms independently; ellipse ≠ strain ellipse;
(g) deformation of material (c): unit circle deforms independently; ellipse ≠ strain ellipse.

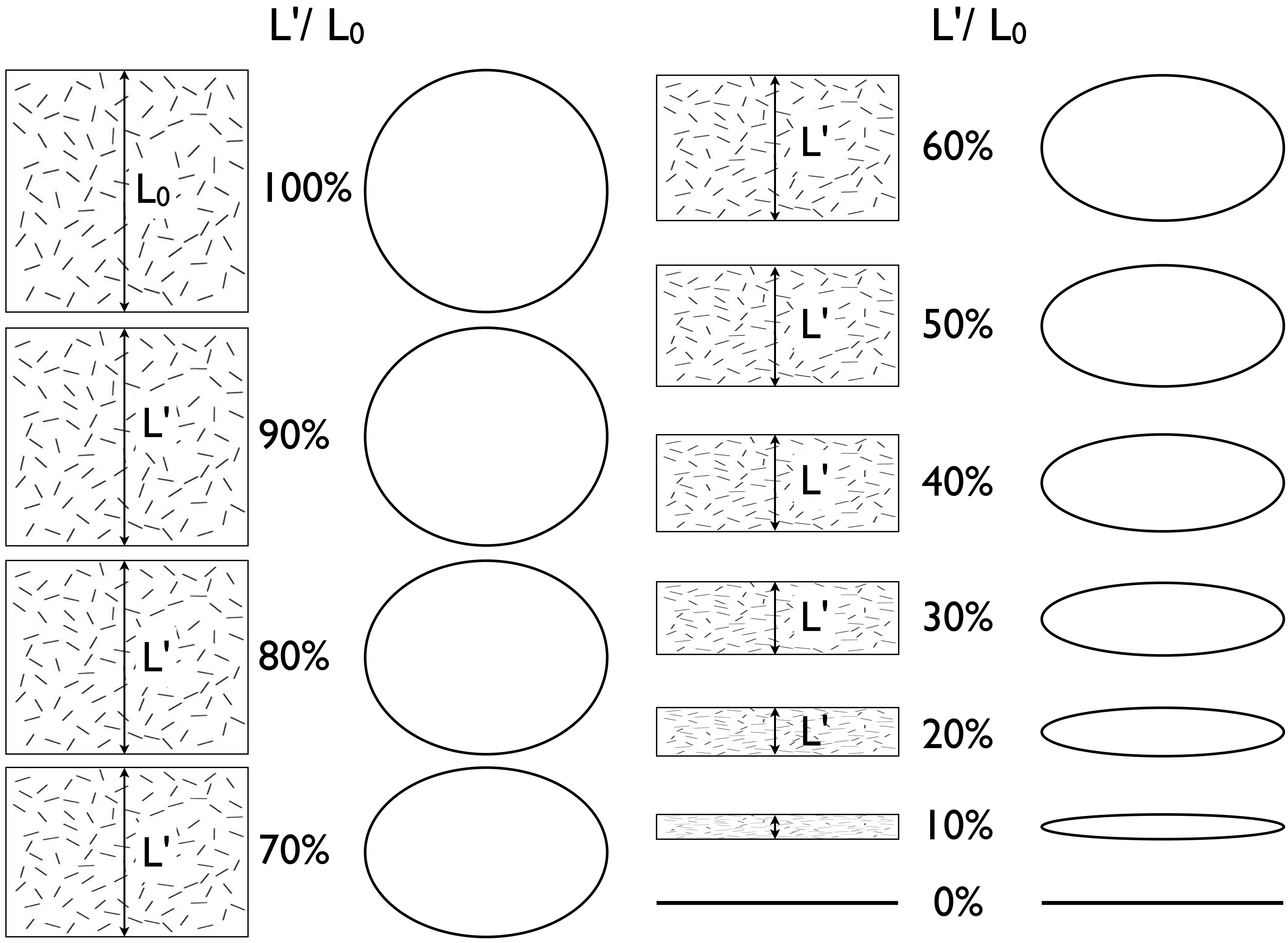

Figure 16.5
Strained sets of randomly oriented lines and characteristic shapes.
Lines are deformed by vertical shortening (pure shear); percentage indicates deformed length, L', as fraction of undeformed length, L_0.

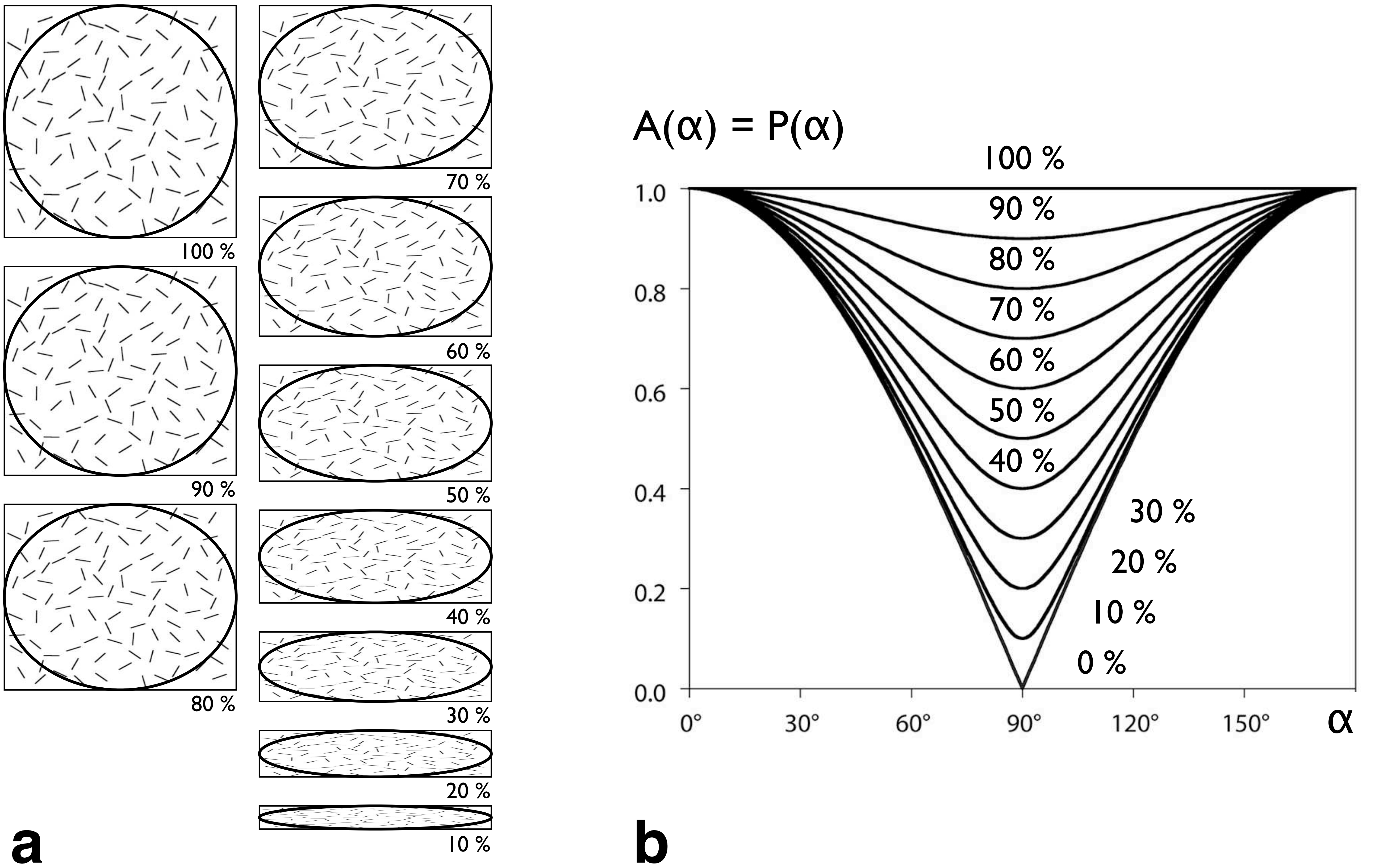

Figure 16.6
Strained sets of randomly oriented lines and projection curves.
Lines are deformed by vertical shortening (pure shear).
(a) Line segments with superposed characteristic shapes (= strain ellipses);
(b) projection curve, $A(\alpha)$, of strained line segments = projection curve $P(\alpha)$ of strain ellipse;
percentage indicates deformed length, L' (= short axis b of strain ellipse), as fraction of undeformed length, L_0 (= long axis a of strain ellipse).

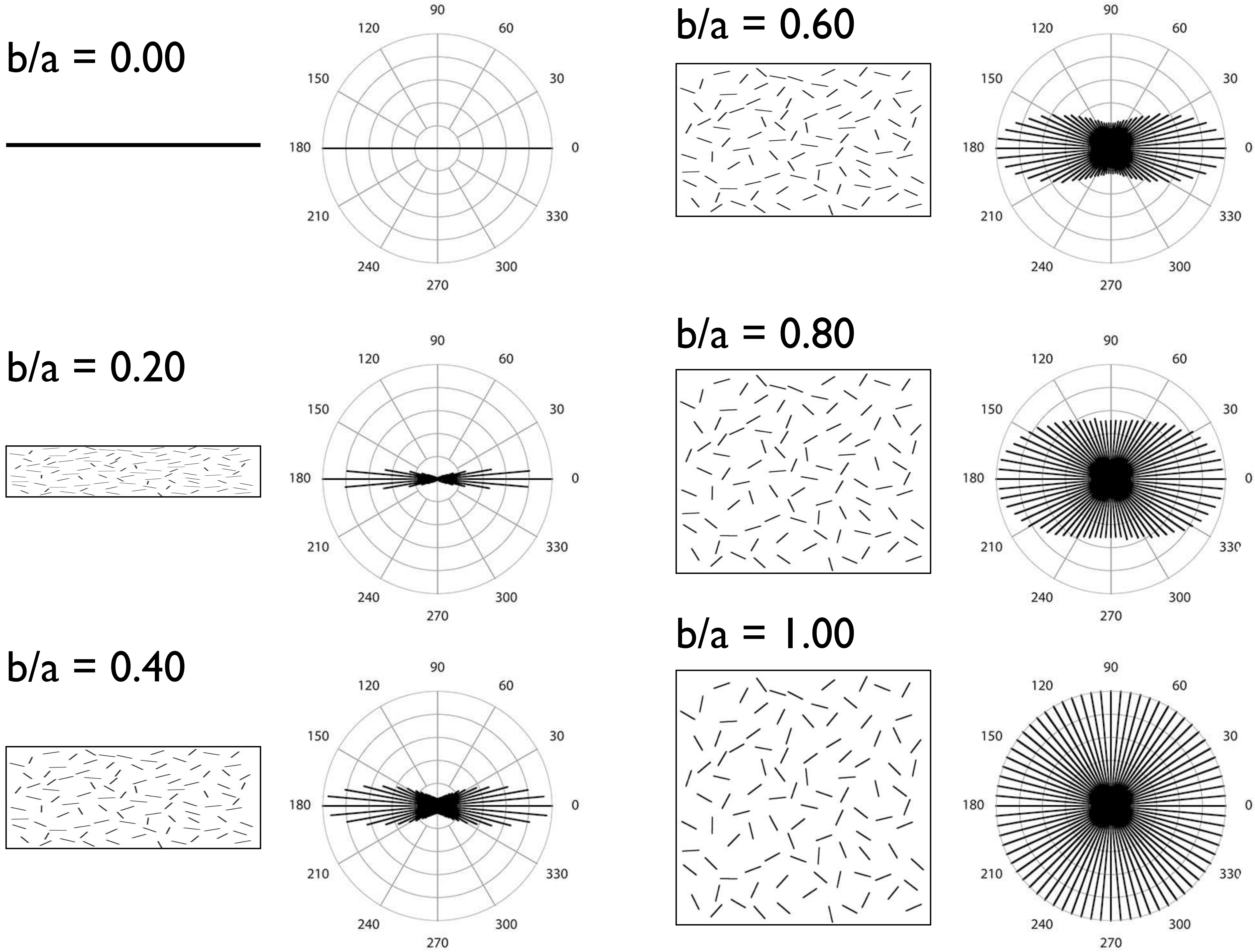

Figure 16.7
Strained sets of randomly oriented lines and rose diagrams of ODF.
Lines are deformed by vertical shortening (pure shear); ODF of line segments are shown on right; axial ratio of strain ellipse is indicated.

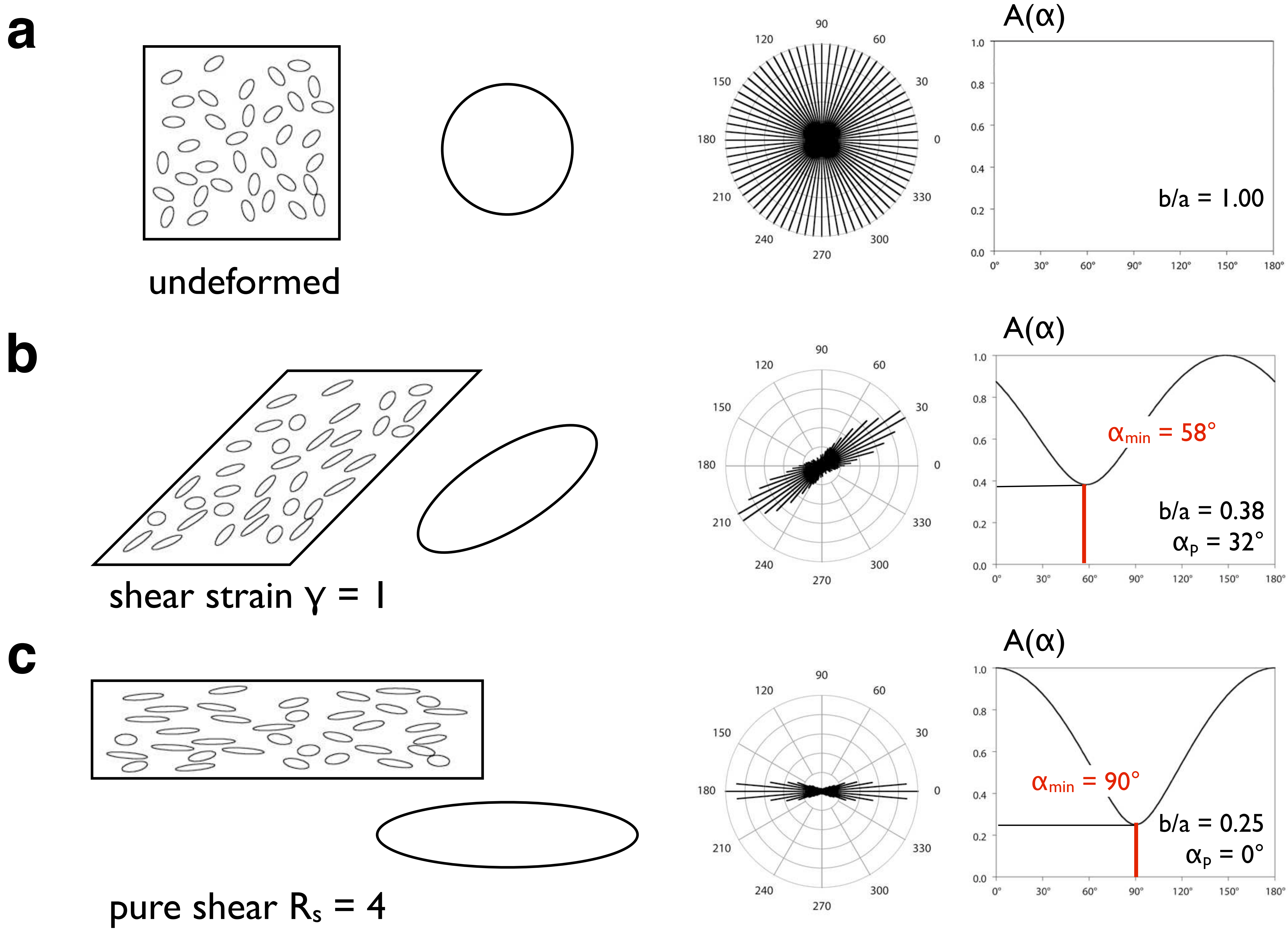

Figure 16.8
Strained randomly oriented ellipses.
From left to right: outlines of ellipses, characteristic shape, ODF of line segments, projection curve $A(\alpha)$:
(a) undeformed: characteristic shape = unit circle;
(b) strained, simple shear γ = 1.00: characteristic shape = strain ellipse with b/a = 0.38 (R = 2.62) and α_p (= φ) = 32°;
(c) strained, pure shear R = 4.00: characteristic shape = strain ellipse with b/a = 0.25 (R = 4.00) and α_p (= φ) = 0°.

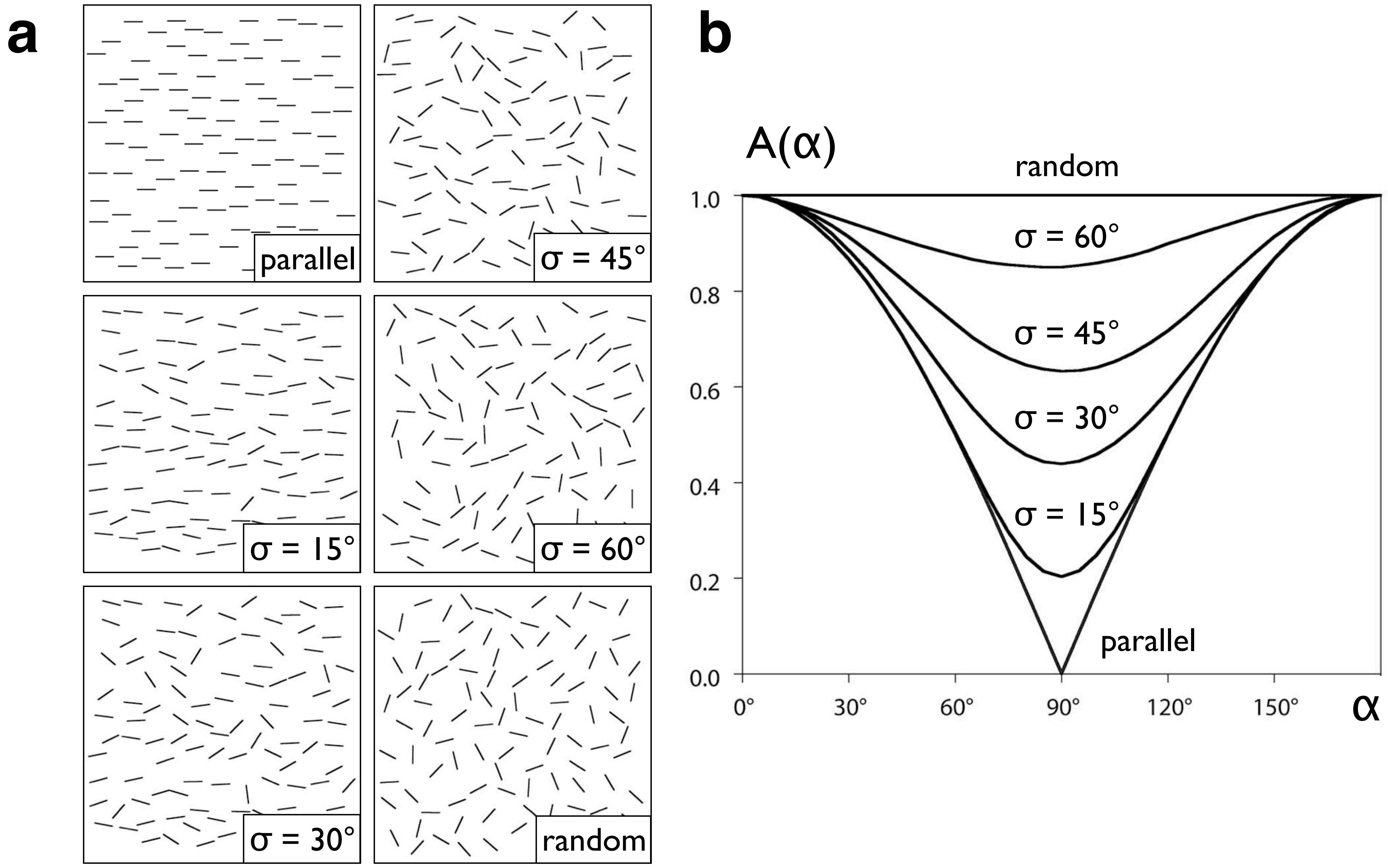

Figure 16.9
Projection curves of lines with different orientation distributions.
(a) Line segments with different orientation distributions;
(b) projection curves, $A(\alpha) = B(\alpha)$, of the line segments;
the mean of the normal distributions is always $\mu = 0°$; different standard deviations, σ, are indicated.

1000 lines	b/a SURFOR 5°
random	0.96
σ = 60°	0.85
σ = 45°	0.63
σ = 30°	0.44
σ = 20°	0.30
σ = 15°	0.20
σ = 10°	0.14
σ = 0° (parallel)	0.00

Table 16.1
Surface anisotropy of sets of 1000 randomly oriented lines.
Axial ratios, b/a, measured as A_{min} / A_{max} of SURFOR analysis.

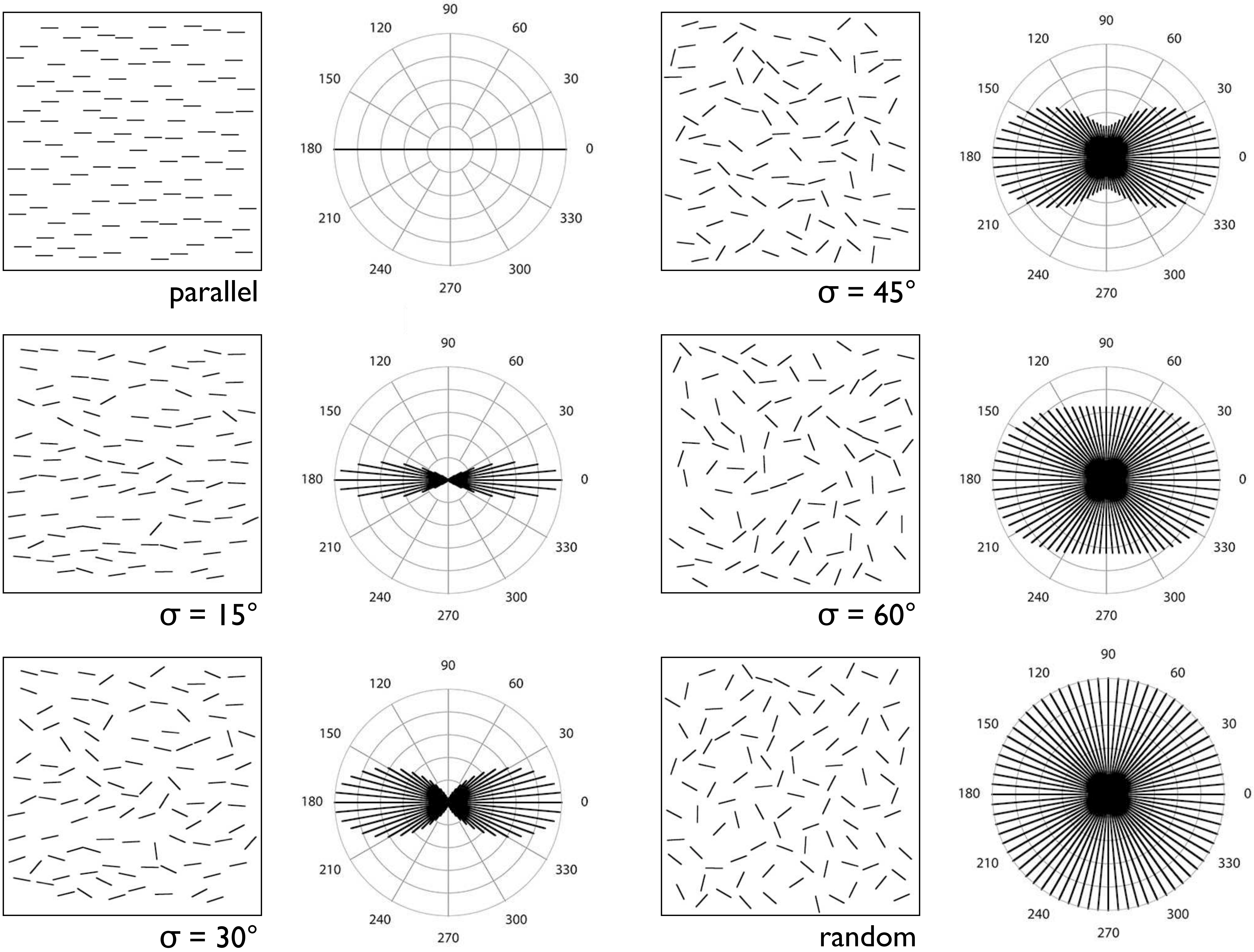

Figure 16.10
Sets of lines with different orientation distributions.
Line segments with different orientation distributions are shown on left; ODF of line segments (rose diagrams) are shown on right; the mean of the normal distributions is always $\mu = 0°$; different standard deviations, σ, are indicated.

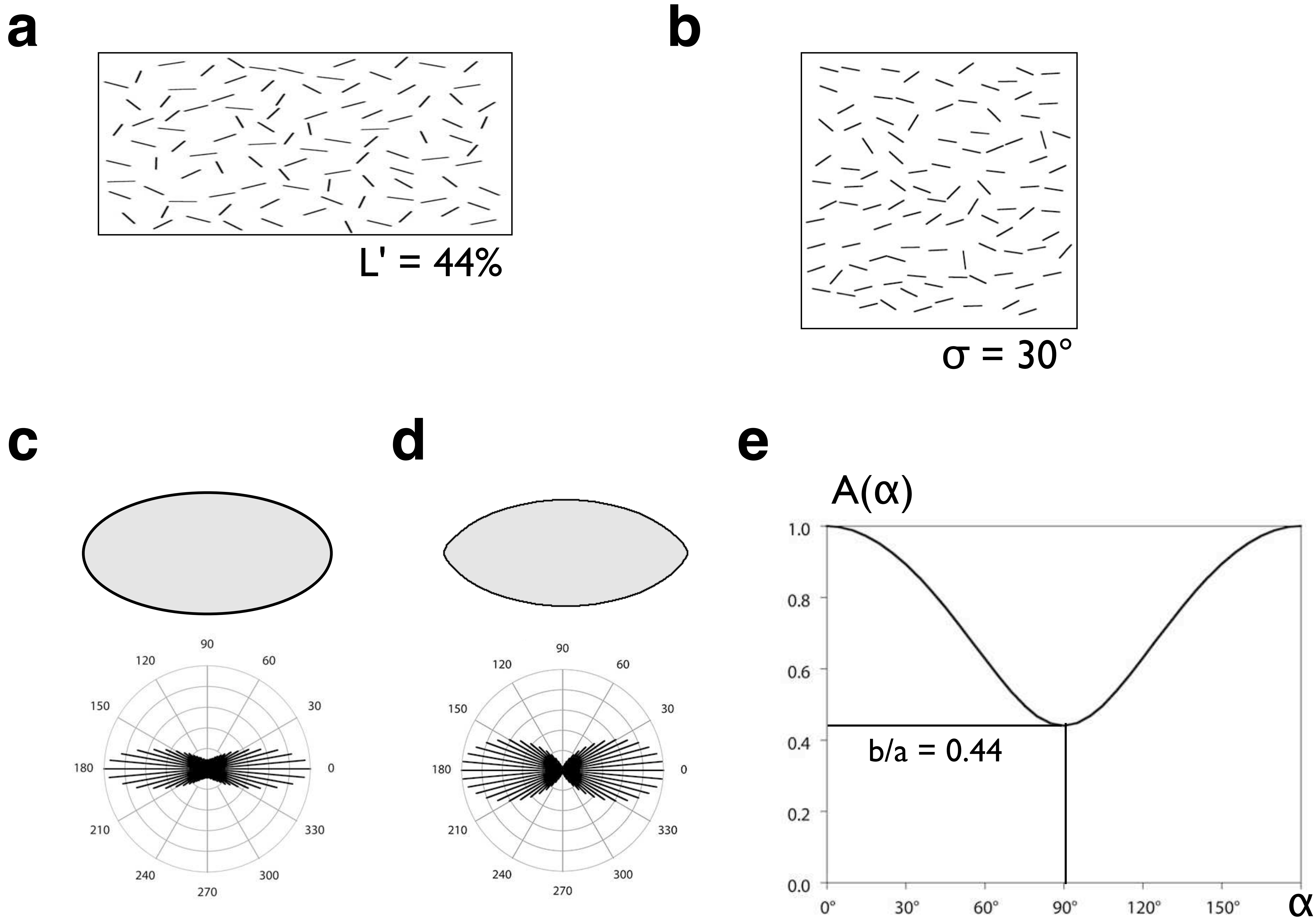

Figure 16.11
Creating preferred orientations by strain or by a random process.
(a) Vertically strained (shortened) set of originally randomly oriented lines;
(b) lines with preferred orientation: Gaussian normal distribution with $\mu = 0°$ and $\sigma = 30°$;
(c) characteristic shape and ODF of line segments for (a);
(d) characteristic shape and ODF of line segments for (b);
(e) (identical) projection curves for (a) and (b).

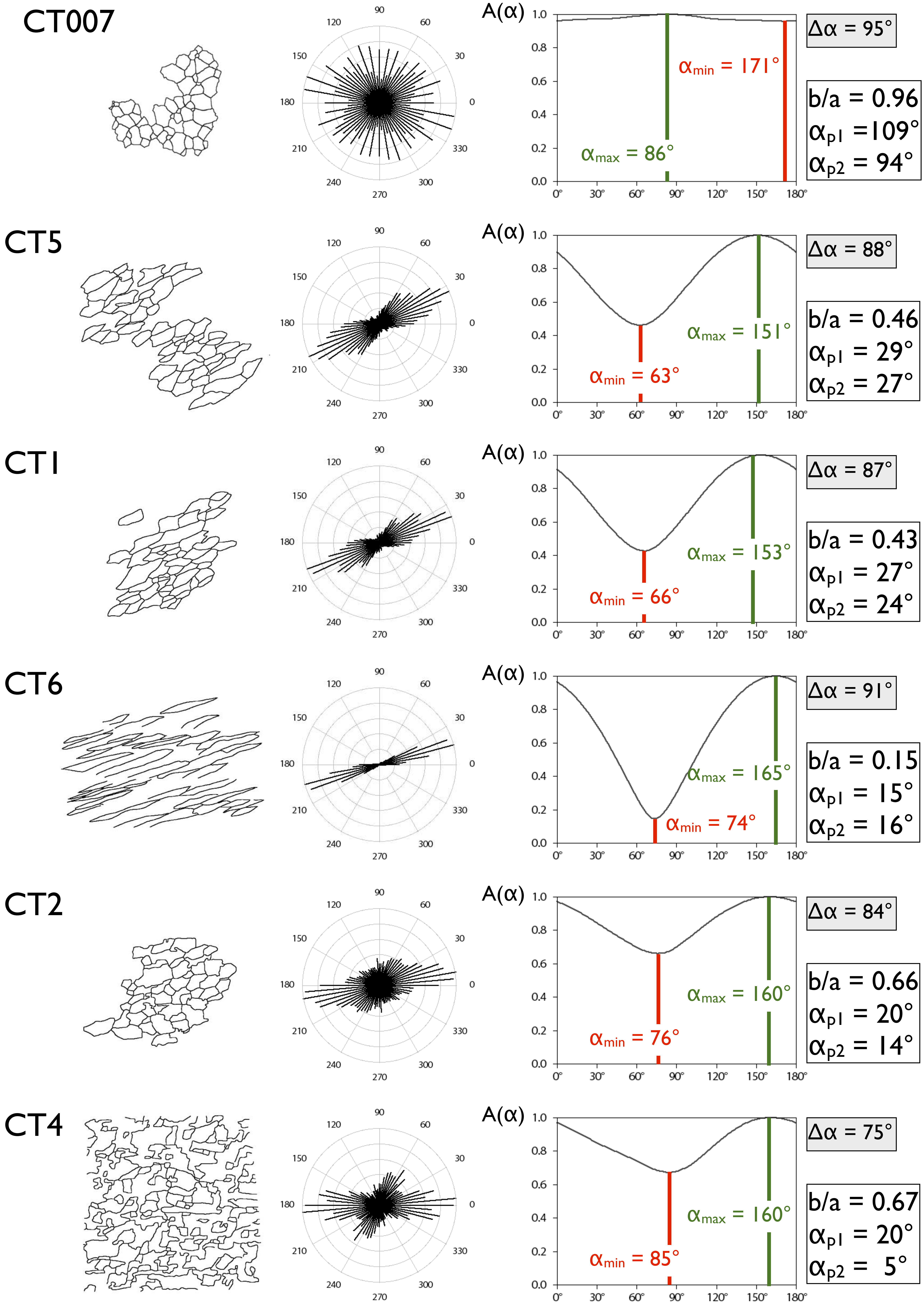

Figure 16.12

SURFOR analysis of experimentally sheared marble.

Grain boundary maps, ODFs of line segments and projection curves, A(α), are shown.

'Strain test': ODF of line segments in rose diagram must be mirror symmetric about preferred orientation.

file.apl	T (°C)	reg.	γ	$b/a(\gamma)$	$\alpha_P(\gamma)$	b/a	α_P
CT007	-		undef	1.00	45°	0.96	94°
CT5	500	twin	1.08	0.36	31°	0.46	27°
CT1	600	twin	1.22	0.32	29°	0.43	24°
CT6	700	i-slip	2.85	0.10	18°	0.15	16°
CT2	800	gbm	0.63	0.54	36°	0.66	15°
CT4	900	gbm	1.31	0.29	28°	0.67	6°
				result of SURFOR		applied shear strain	

Table 16.2
Axial ratios and preferred orientations of surface fabric of experimentally deformed marble.
Samples from Schmid et al. (1987).
T (°C) = temperature during experiment;
reg. = microfabric regime: twin = twinning; i-slip = intracrystalline slip; gbm = grain boundary migration;
γ = applied shear strain;
$b/a(\gamma)$ = axial ratio, b/a, calculated for applied shear strain;
α_P (γ) preferred orientation, α_P, calculated for applied shear strain;
b/a = axial ratio, b/a, determined by SURFOR;
α_P = preferred orientation, α_{P2}, determined by SURFOR.

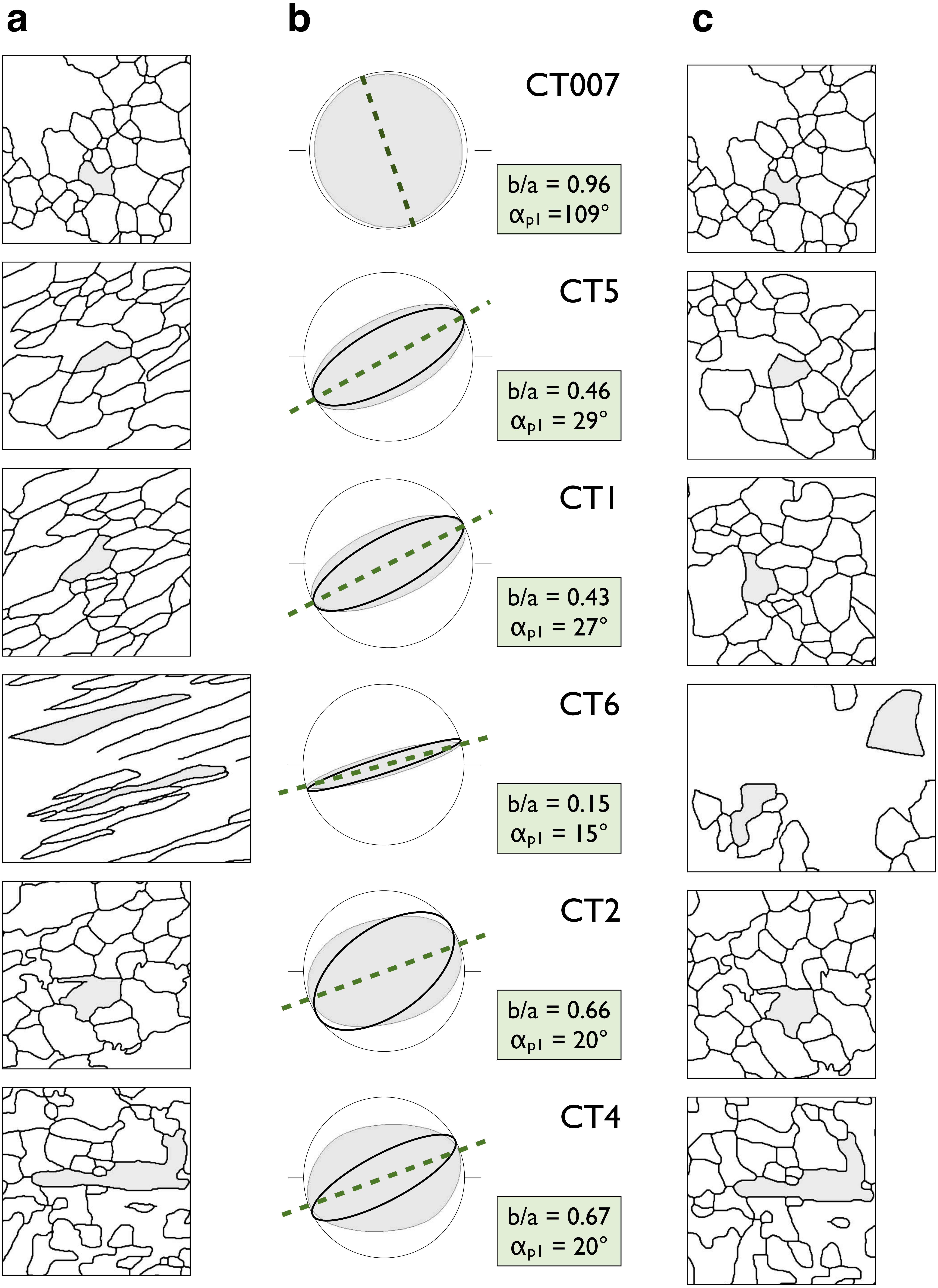

Figure 16.13

Surface fabrics of experimentally deformed marble.

For compilation of SURFOR analysis, see Table 16.2. (a) Outlines of experimentally deformed samples; (b) gray = characteristic shape; black outline = superposed strain ellipse calculated for applied shear strain; stippled line = preferred orientation α_{p1}; (c) un-strained version of (a) using values b/a and α_{p1} derived by SURFOR analysis; a few grains are shaded to facilitate comparison between(a) and (c).

	file	mean axial ratio b/a	mean ratio P/P_{equ}
undeformed	ct007	0.70	1.16
numerically restored (unstrained)	ct5	0.71	1.20
	ct1	0.64	1.23
	ct6	0.60	1.27
	ct2	0.63	1.31
	ct4	0.61	1.28

Table 16.3
Analysis of unstrained samples.
Mean axial ratio, b/a, of all grains of the microstructure; b= short axis and a = long axis of best-fit ellipse (Analyze menu); mean ratio, P/P_{equ}; P = measured perimeter of grain and P_{equ} = perimeter of area equivalent circle.

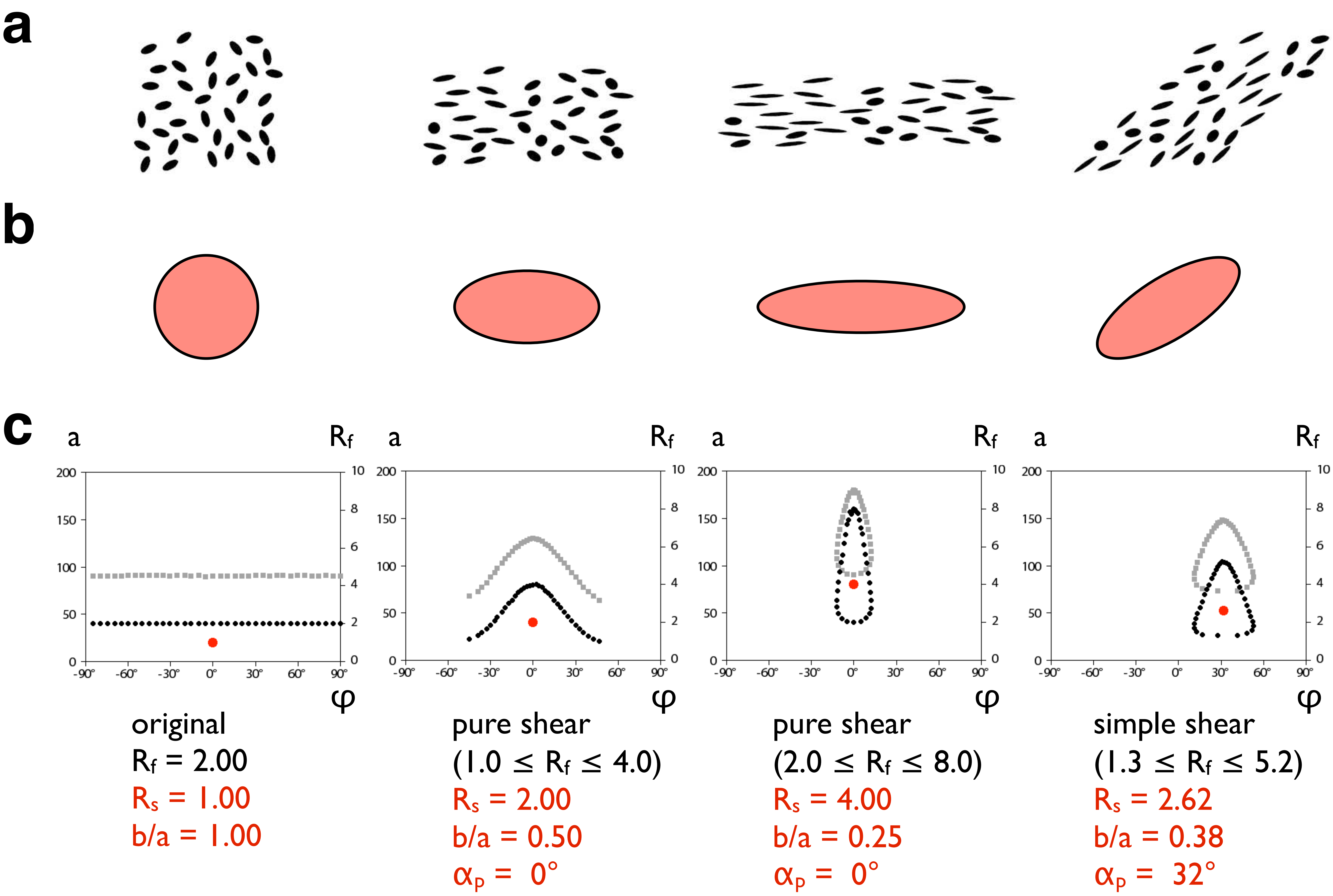

Figure 16.14
Strain analysis using SURFOR and R_f - φ method.
(a) Sets of variously strained ellipses;
(b) characteristic shapes (result of SURFOR analysis using 1° resolution);
(c) R_f - φ diagrams; black circles = values of aspect ratio, R_f; gray squares = long axes, a, (= size) of ellipses; red dots = strain;
R_f = aspect ratio of ellipses; R_s (= a/b) = aspect ratio of strain ellipse; b/a (=1 / R_s) = axial ratio of characteristic shape; α_p (= φ) = orientation of characteristic shape; note that characteristic shape = strain ellipse.

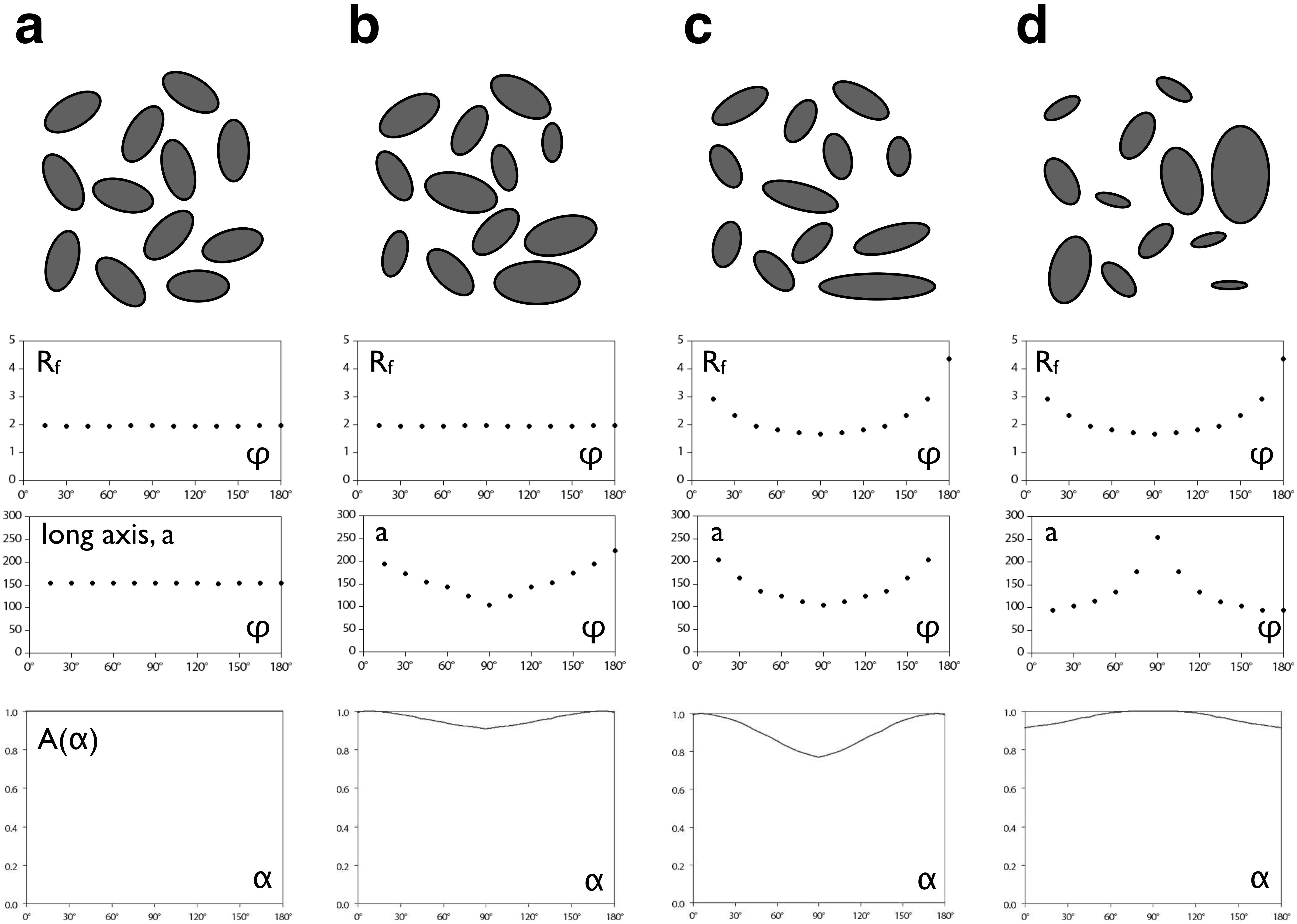

Figure 16.15
Comparison of SURFOR and R_f - φ method.
Four sets of ellipses are shown; below: R_f - φ plot, plot of long axis versus φ, and projection curve, $A(\alpha)$; long axis, a, is used to denote size of ellipses, R_f (= a/b) of ellipses.
(a) Randomly oriented ellipses, identical size, identical aspect ratio: SURFOR: isotropic; R_f - φ: isotropic;
(b) randomly oriented ellipses, varying size, identical aspect ratio: SURFOR: preferred orientation = horizontal; R_f - φ: isotropic;
(c) randomly oriented ellipses: varying size, varying aspect ratio; SURFOR: preferred orientation = horizontal; R_f - φ: preferred orientation = horizontal;
(d) randomly oriented ellipses: varying size, varying aspect ratio; SURFOR: preferred orientation = vertical; R_f - φ: preferred orientation = horizontal.