The Abdus Salam
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Advanced School on Scaling Laws in Geophysics: Mechanical and Thermal Processes in Geodynamics

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Convection - Part IV

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CONVECTION

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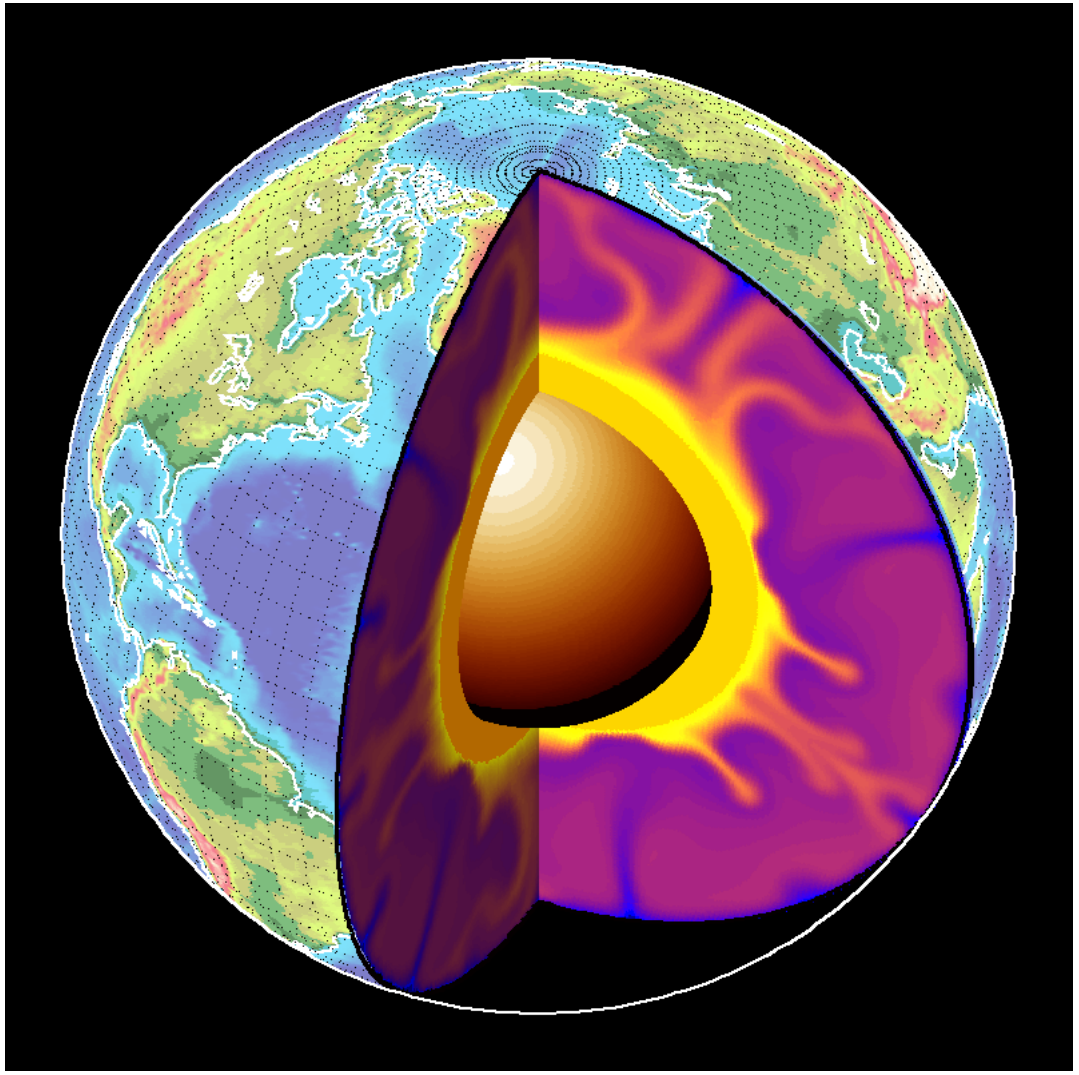
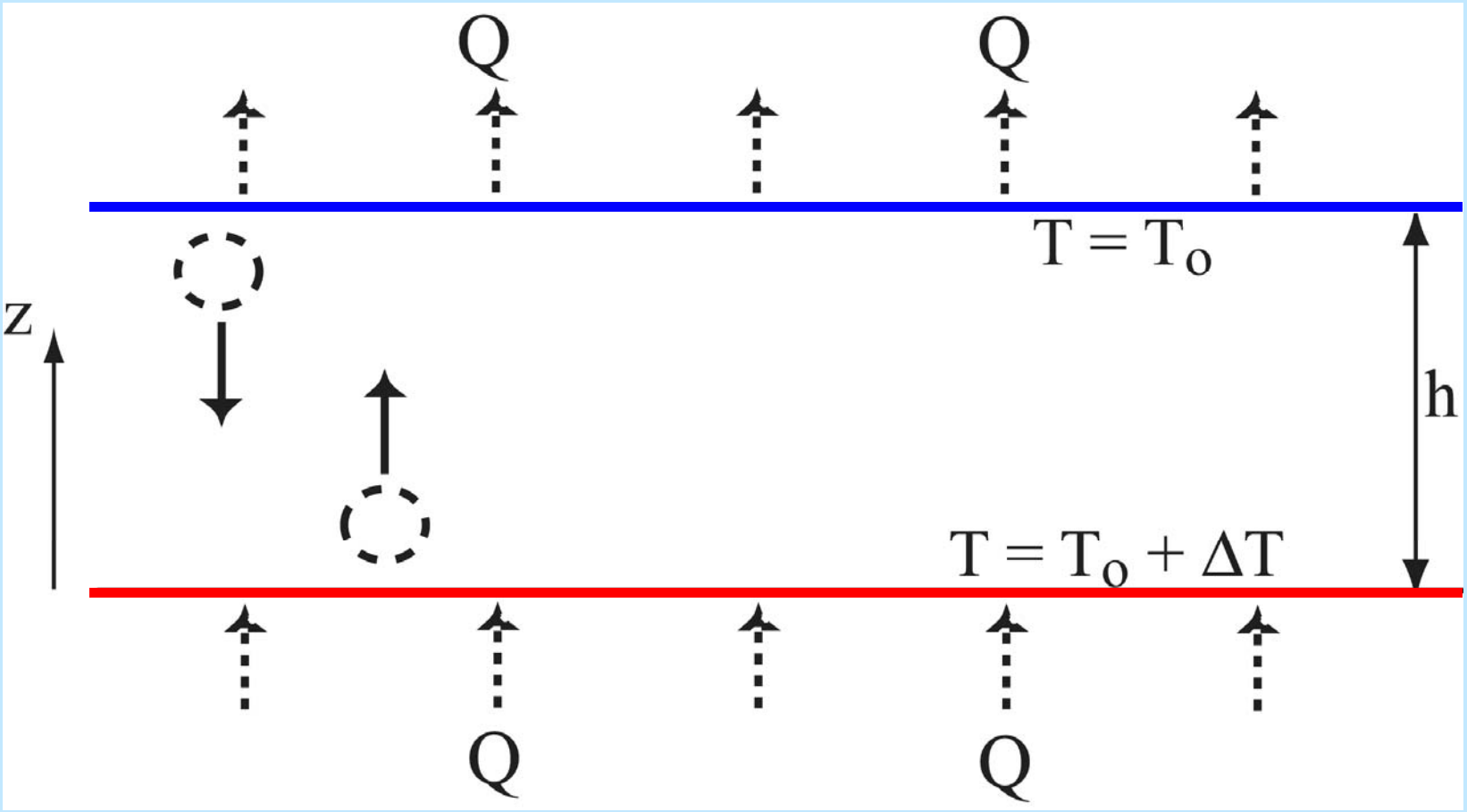
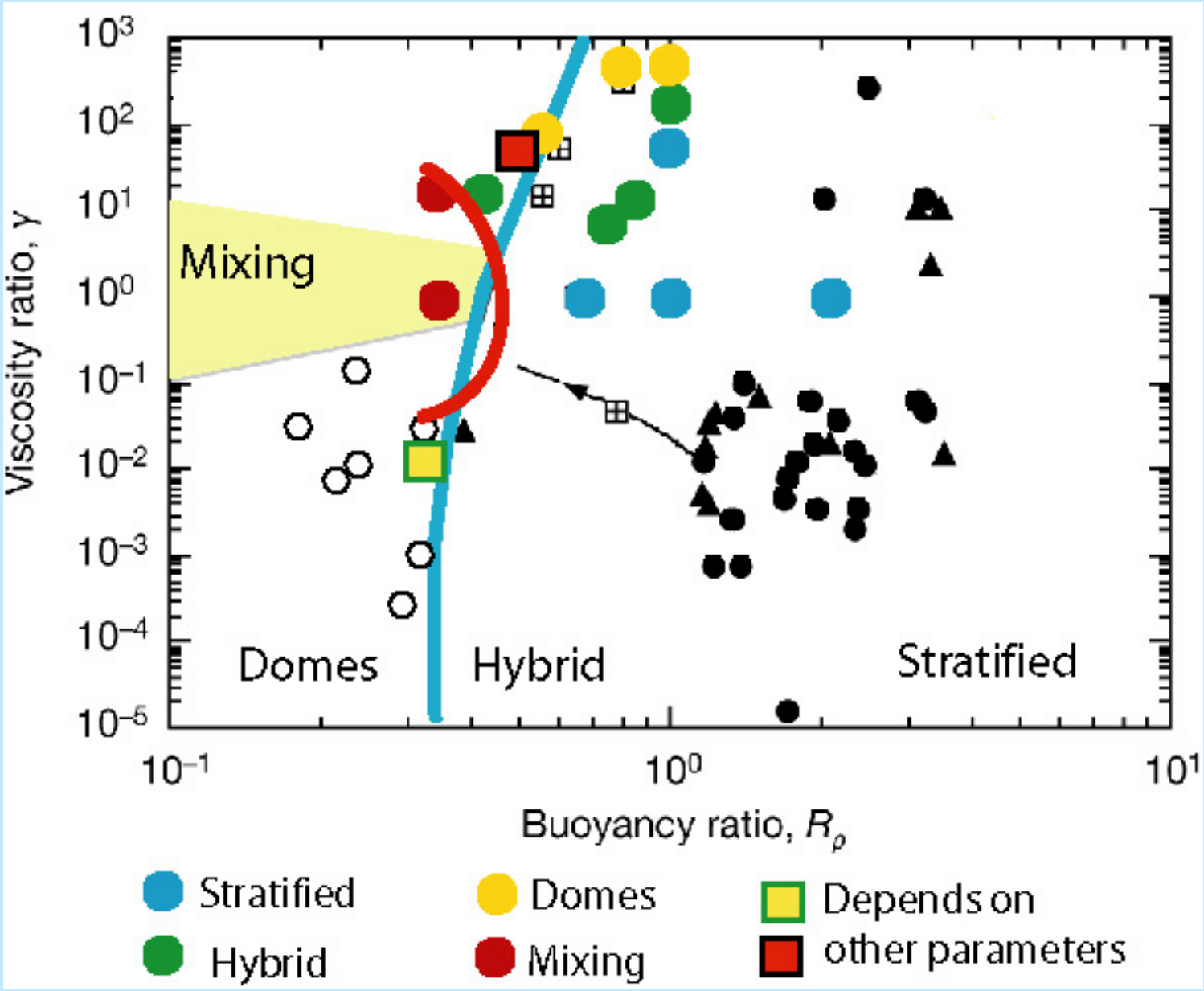
Density stratification in the Earth's mantle

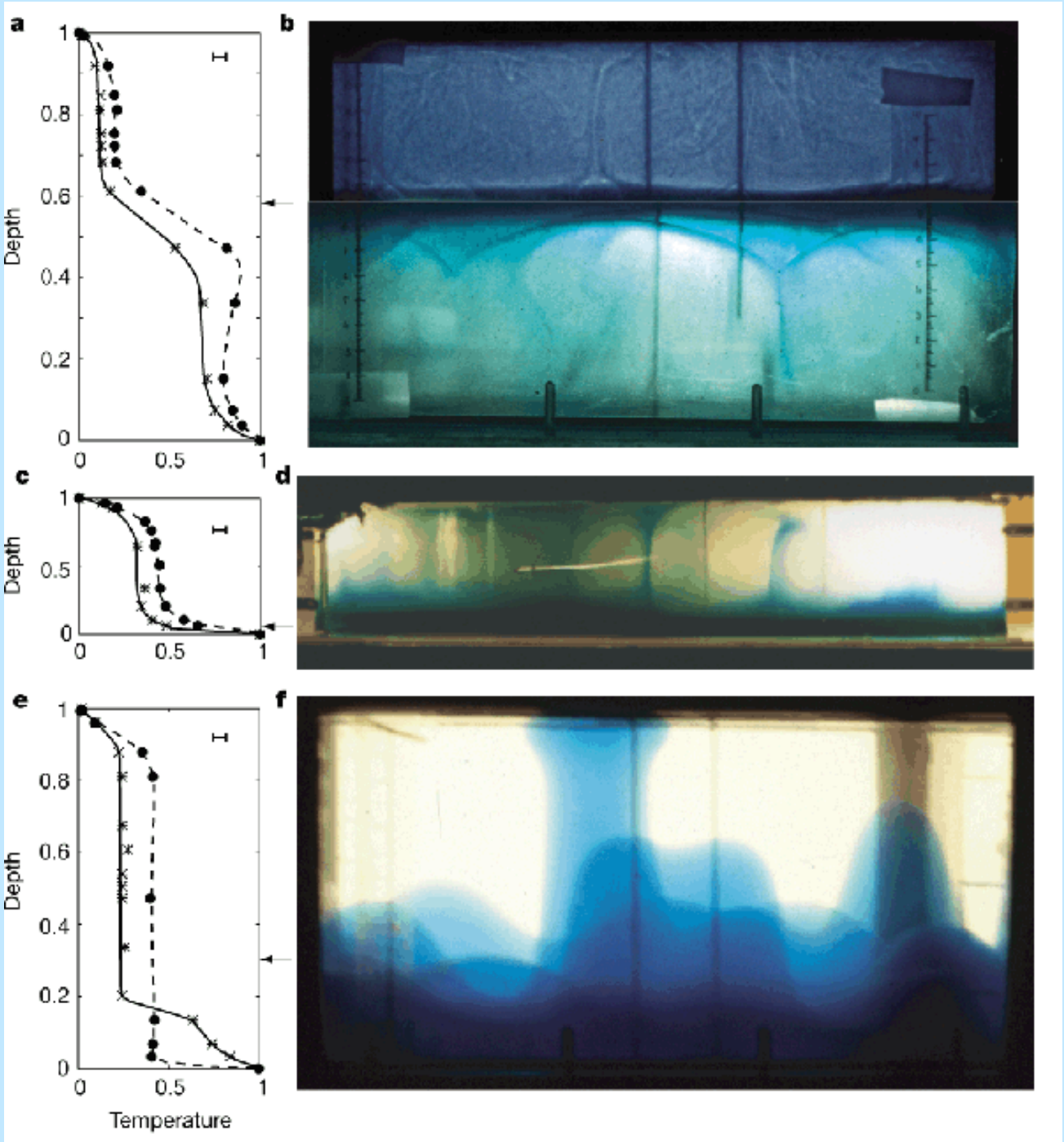


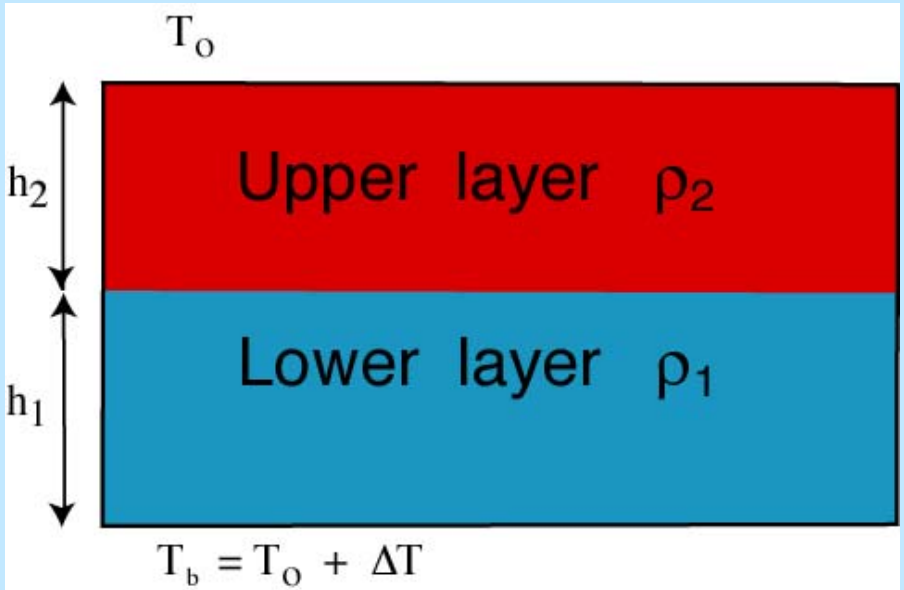

Q
Q
T = T$_o$
z
h
T = T$_o$ + ΔT
Q
Q


Viscosity ratio, γ
10³
10²
10¹
10⁰
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
Mixing
Domes
Hybrid
Stratified
10⁻¹
10⁰
10¹
Buoyancy ratio, R_ρ
Stratified
Hybrid
Domes
Mixing
Depends on other parameters

Layered convection experiments by Anne Davaille,

(Nature *402*, 756, Dec. 1999)



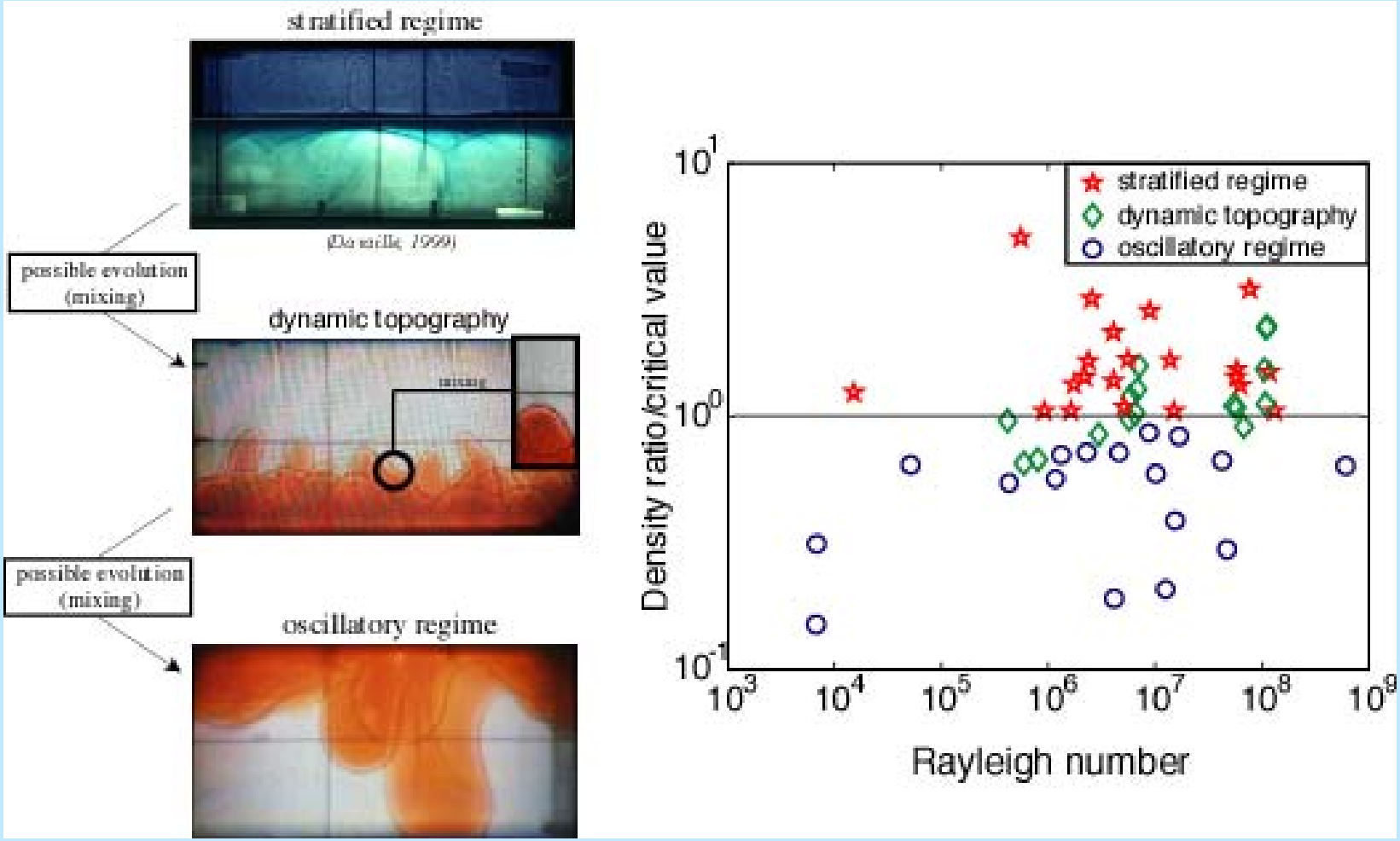


$$Ra = \frac{g\,\alpha\,\Delta T\,h^3}{\kappa\,\nu} \qquad Pr = \nu / \kappa$$

B = density ratio

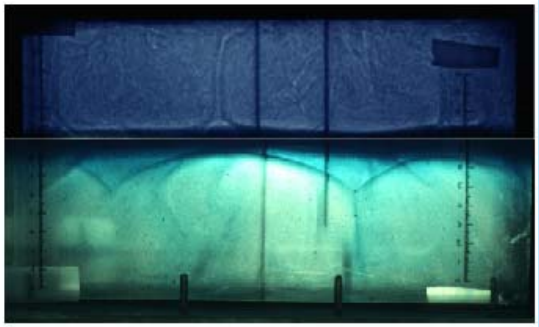
$$= \Delta\rho_C / \Delta\rho_T = (\rho_1 - \rho_2) / \alpha\,\rho\,\Delta T_T$$

Viscosity ratio $= \mu_1 / \mu_2$

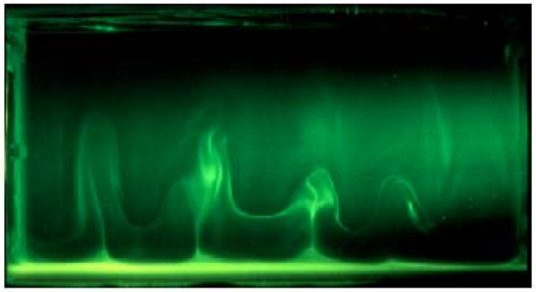

stratified regime
(Da ville, 1999)
possible evolution
(mixing)
dynamic topography
mixing
possible evolution
(mixing)
oscillatory regime
stratified regime
dynamic topography
oscillatory regime
Density ratio/critical value
Rayleigh number
10^{1}
10^{0}
10^{-1}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}
10^{8}
10^{9}

THERMOCHEMICAL CONVECTION : STRATIFIED REGIME

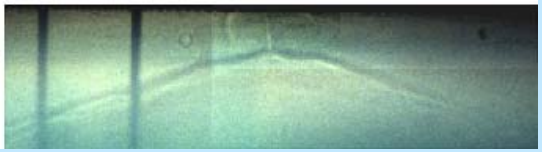
1. Stratified with two convecting layers

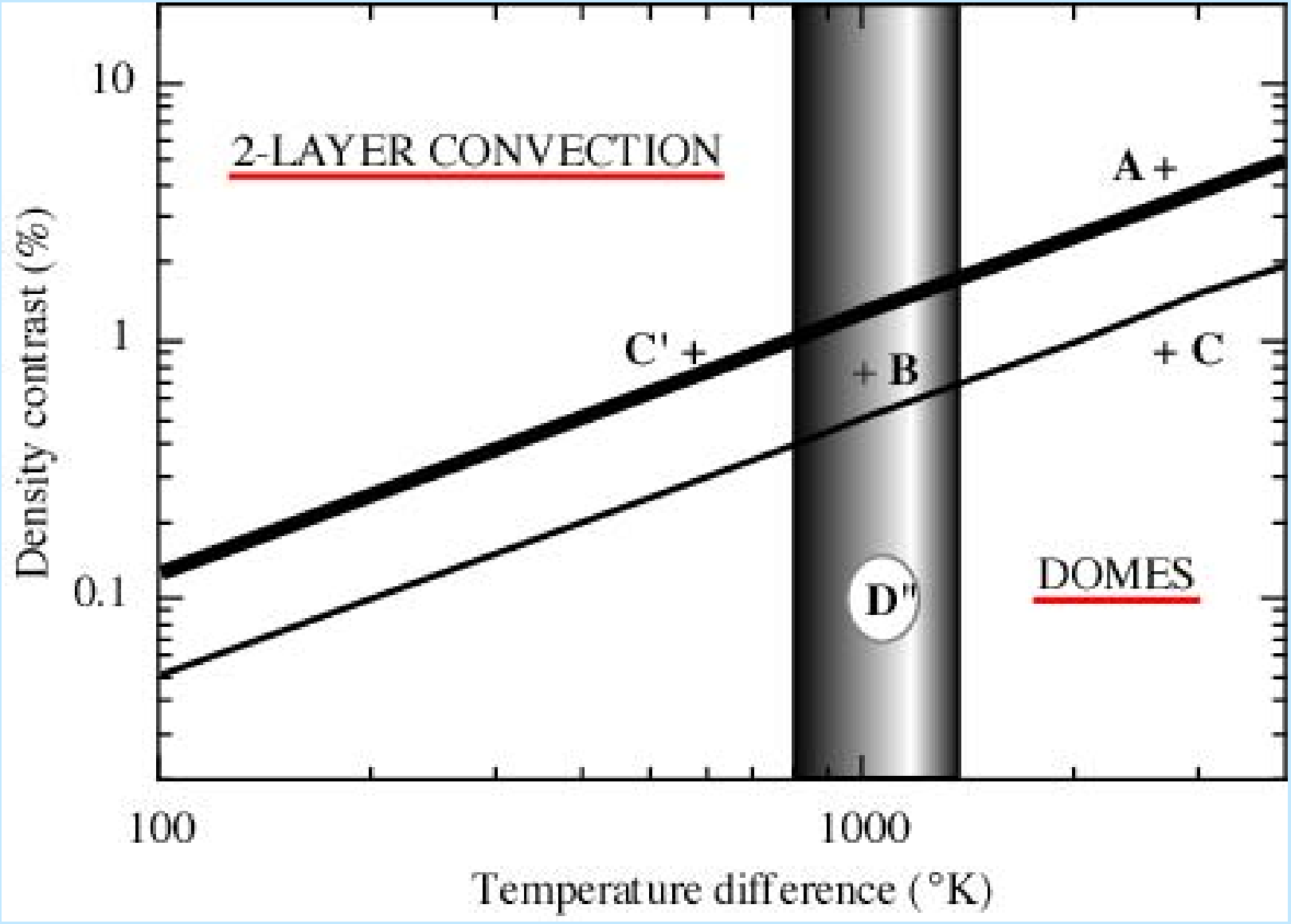


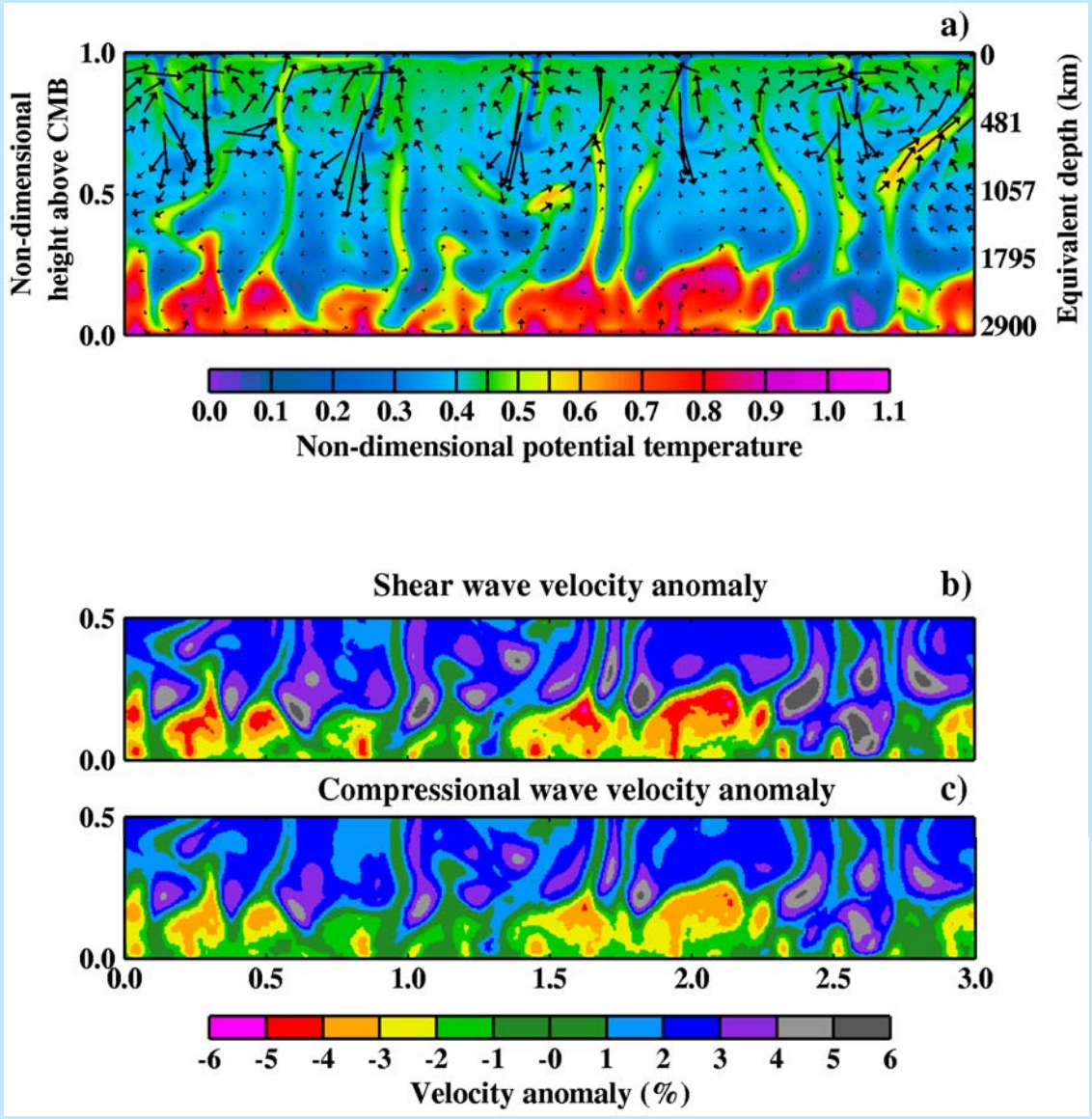
2. Stratified with one convecting layer

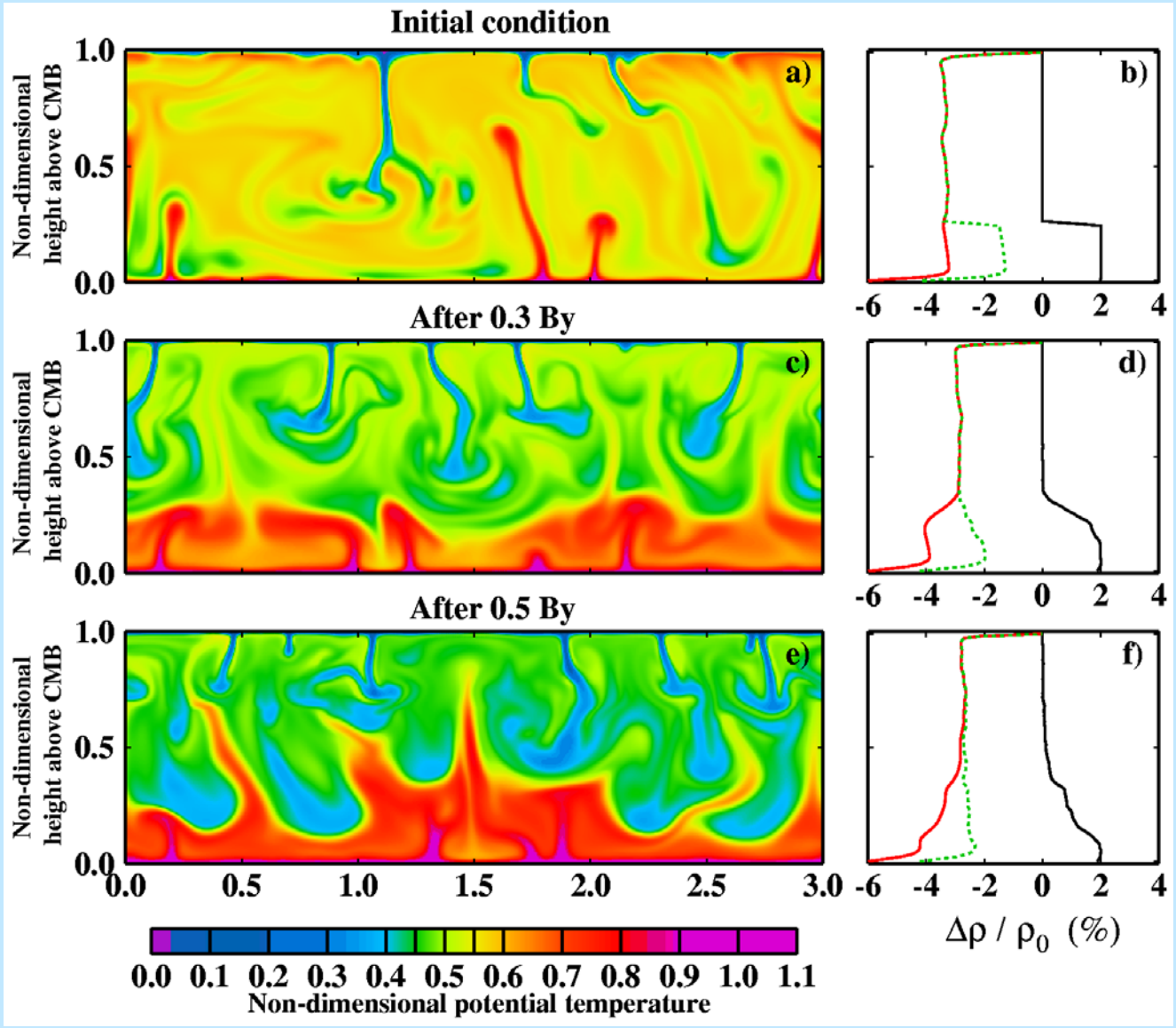


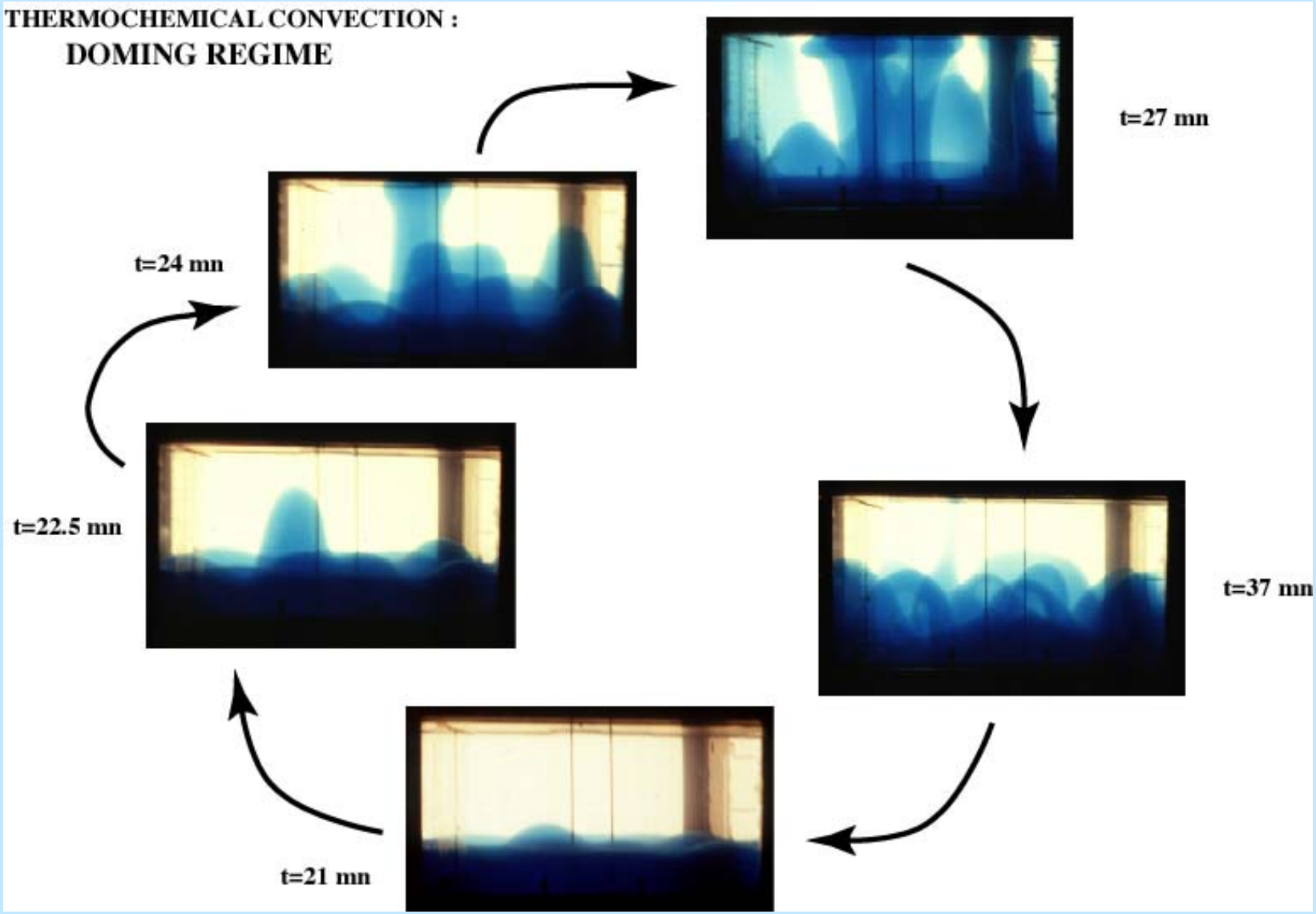
3. Locally stratified above a dome




10
1
0.1
Density contrast (%)
2-LAYER CONVECTION
A +
C' +
+ B
+ C
D''
DOMES
100
1000
Temperature difference (°K)


a)
Non-dimensional height above CMB
1.0
0.5
0.0
0
481
1057
1795
2900
Equivalent depth (km)
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1
Non-dimensional potential temperature
Shear wave velocity anomaly
b)
0.5
0.0
Compressional wave velocity anomaly
c)
0.5
0.0
0.0 0.5 1.0 1.5 2.0 2.5 3.0
-6 -5 -4 -3 -2 -1 -0 1 2 3 4 5 6
Velocity anomaly (%)


Initial condition
After 0.3 By
After 0.5 By
Non-dimensional height above CMB
1.0
0.5
0.0
a)
b)
c)
d)
e)
f)
-6 -4 -2 0 2 4
0.0 0.5 1.0 1.5 2.0 2.5 3.0
Δρ / ρ0 (%)
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1
Non-dimensional potential temperature


THERMOCHEMICAL CONVECTION :
DOMING REGIME
t=27 mn
t=24 mn
t=22.5 mn
t=37 mn
t=21 mn