The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

2240-30

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

23 May - 3 June, 2011

Convective Systems

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CONVECTION

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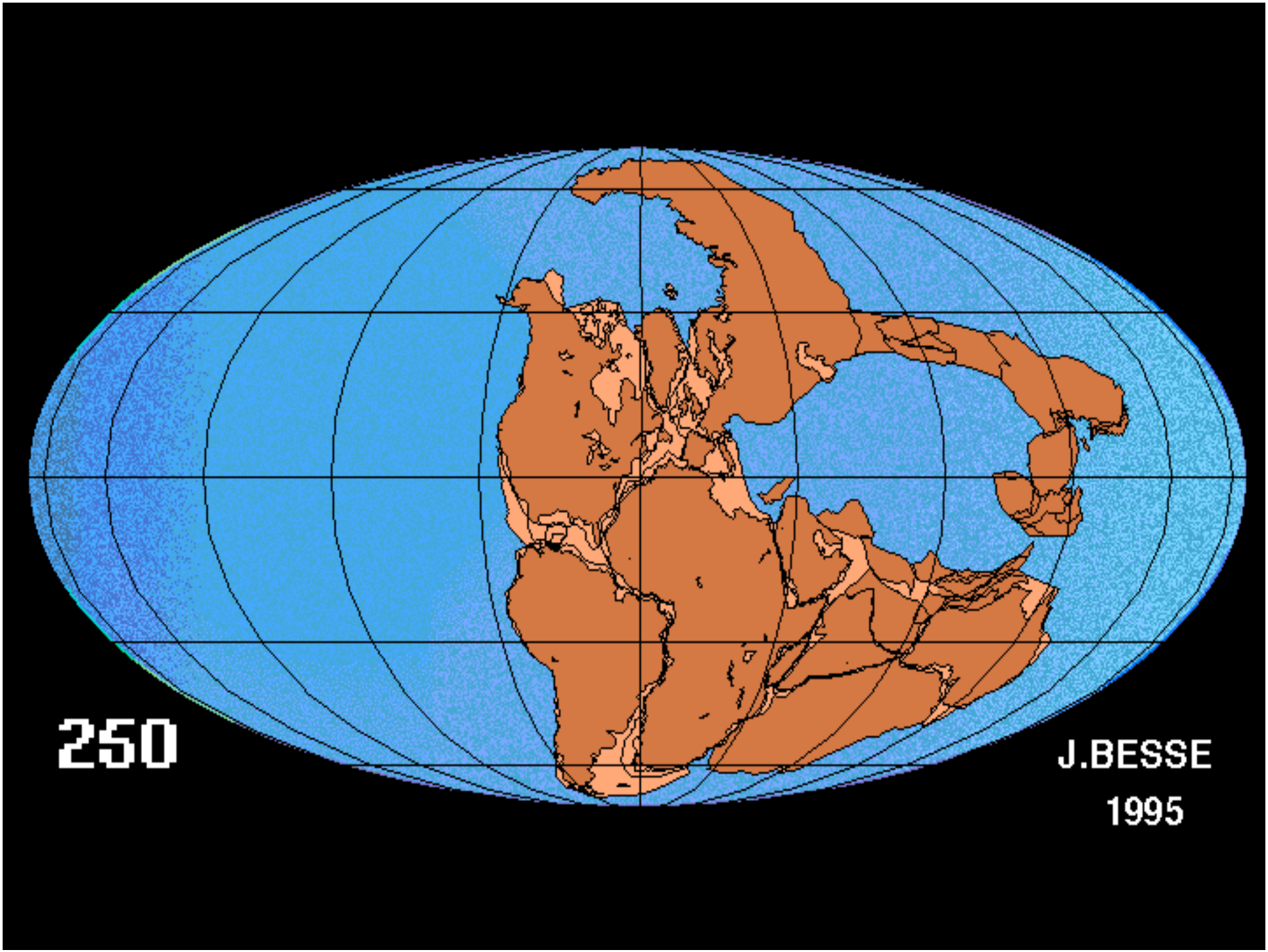
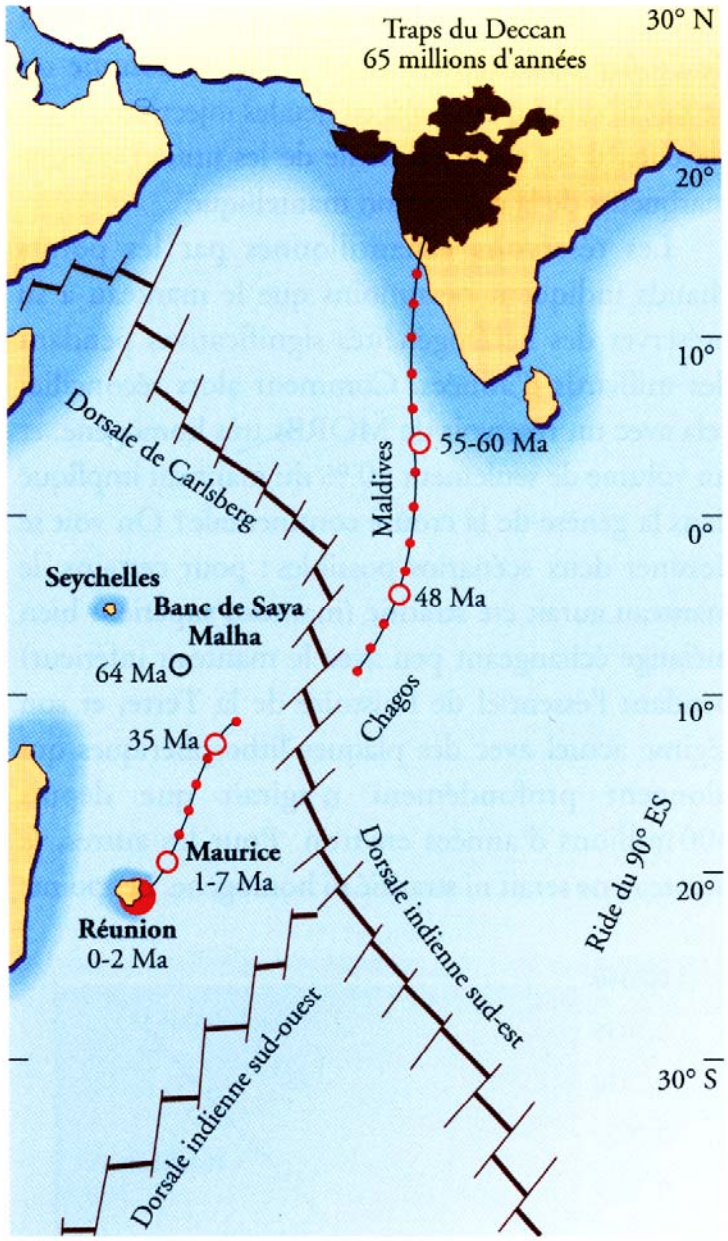
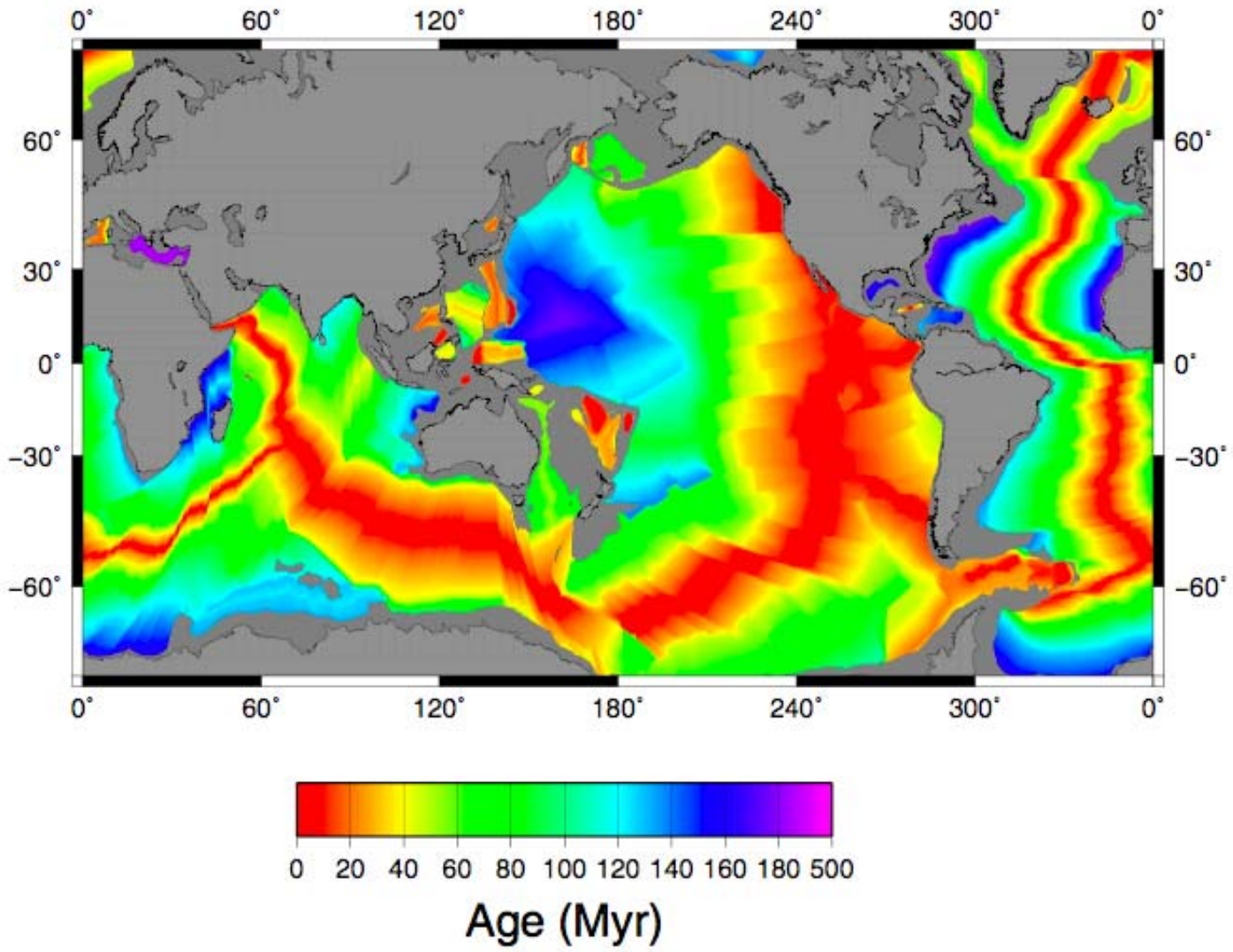
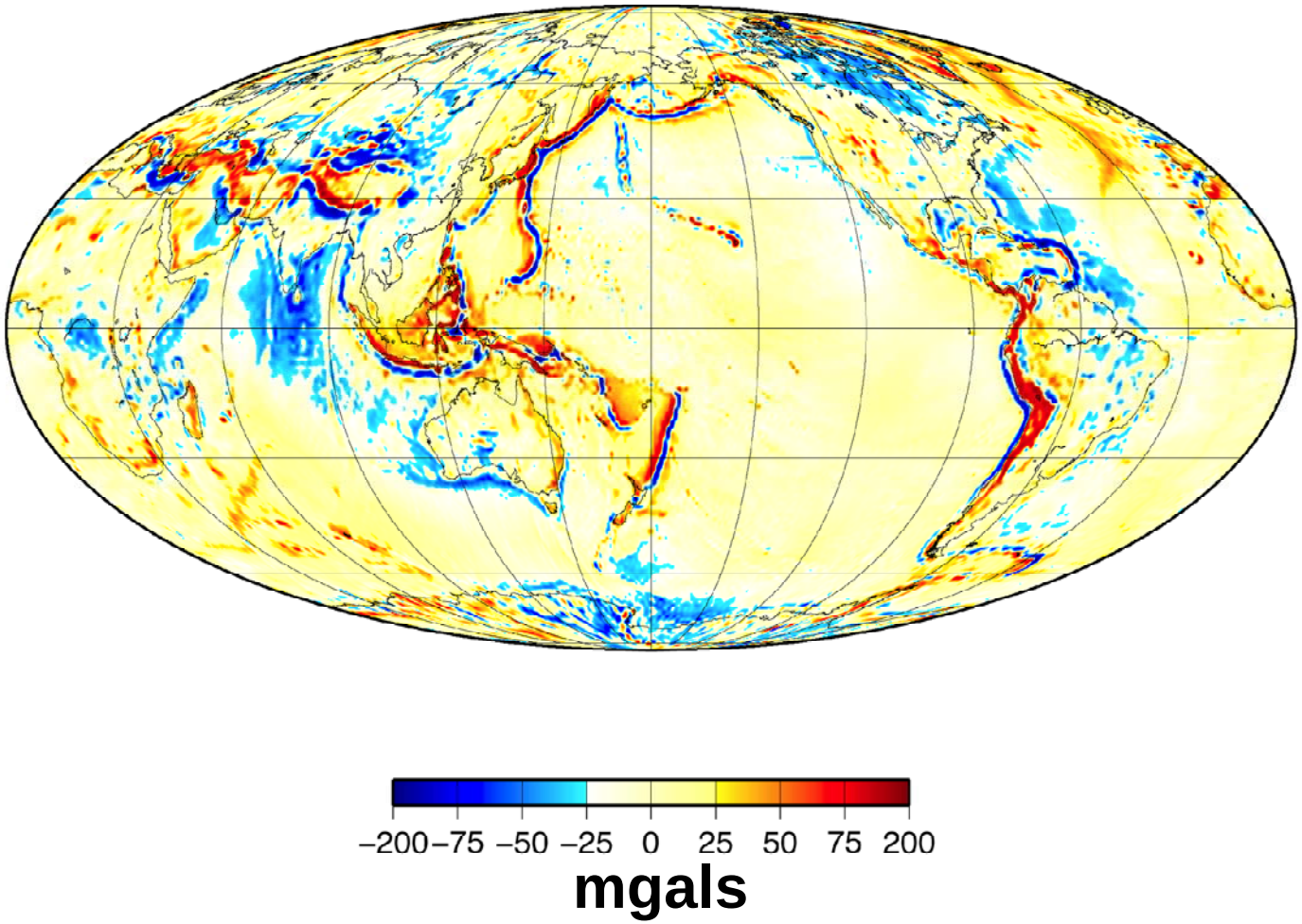

250
J.BESSE
1995


Traps du Deccan
65 millions d'années
30° N
20°
10°
0°
10°
20°
30° S
Dorsale de Carlsberg
Maldives
55-60 Ma
48 Ma
Chagos
Seychelles
Banc de Saya
Malha
64 Ma
35 Ma
Maurice
1-7 Ma
Réunion
0-2 Ma
Dorsale indienne sud-est
Dorsale indienne sud-ouest
Ride du 90° ES

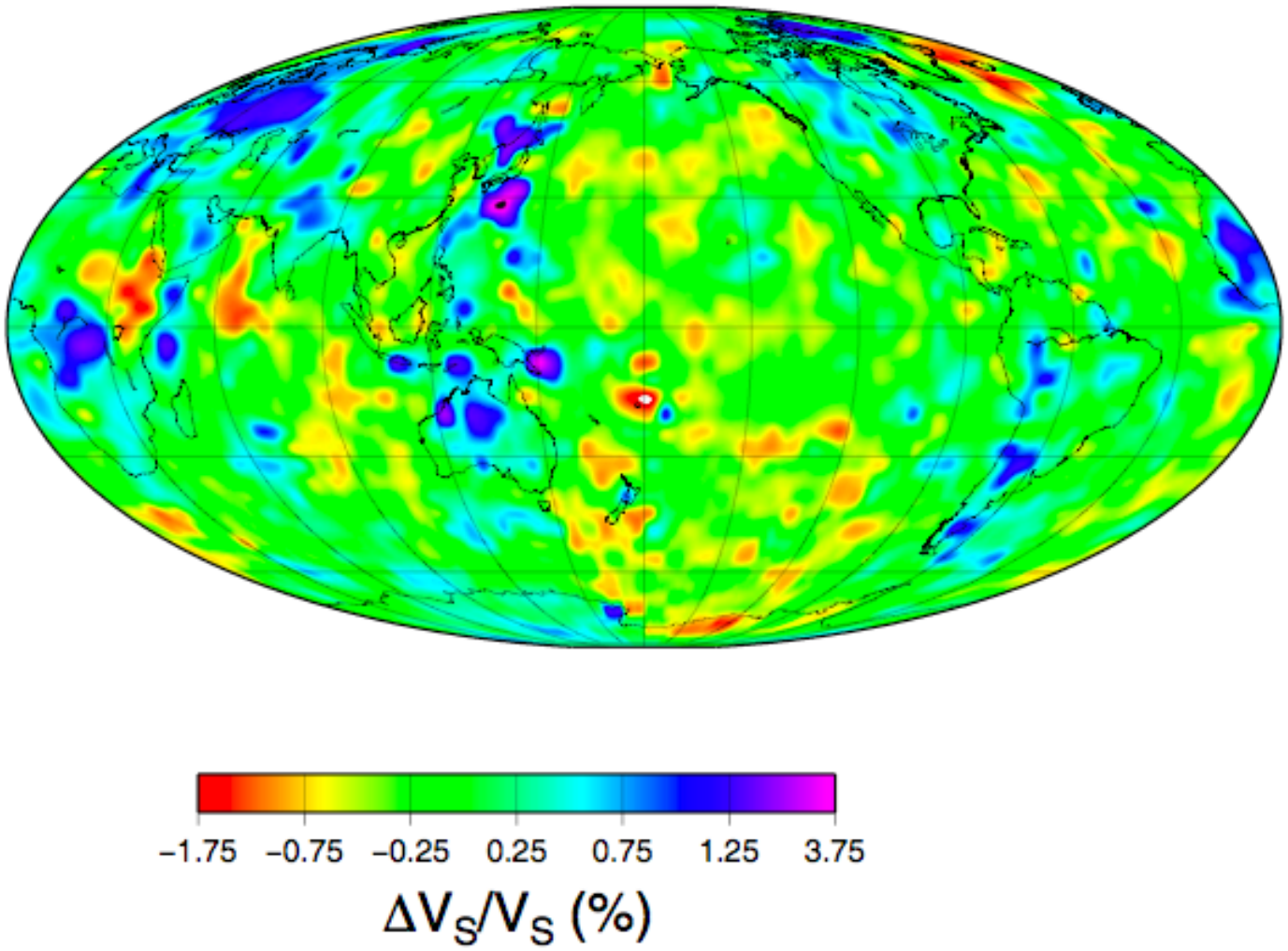

0°
60°
120°
180°
240°
300°
0°
60°
30°
0°
−30°
−60°
0 20 40 60 80 100 120 140 160 180 500
Age (Myr)

Free Air gravity

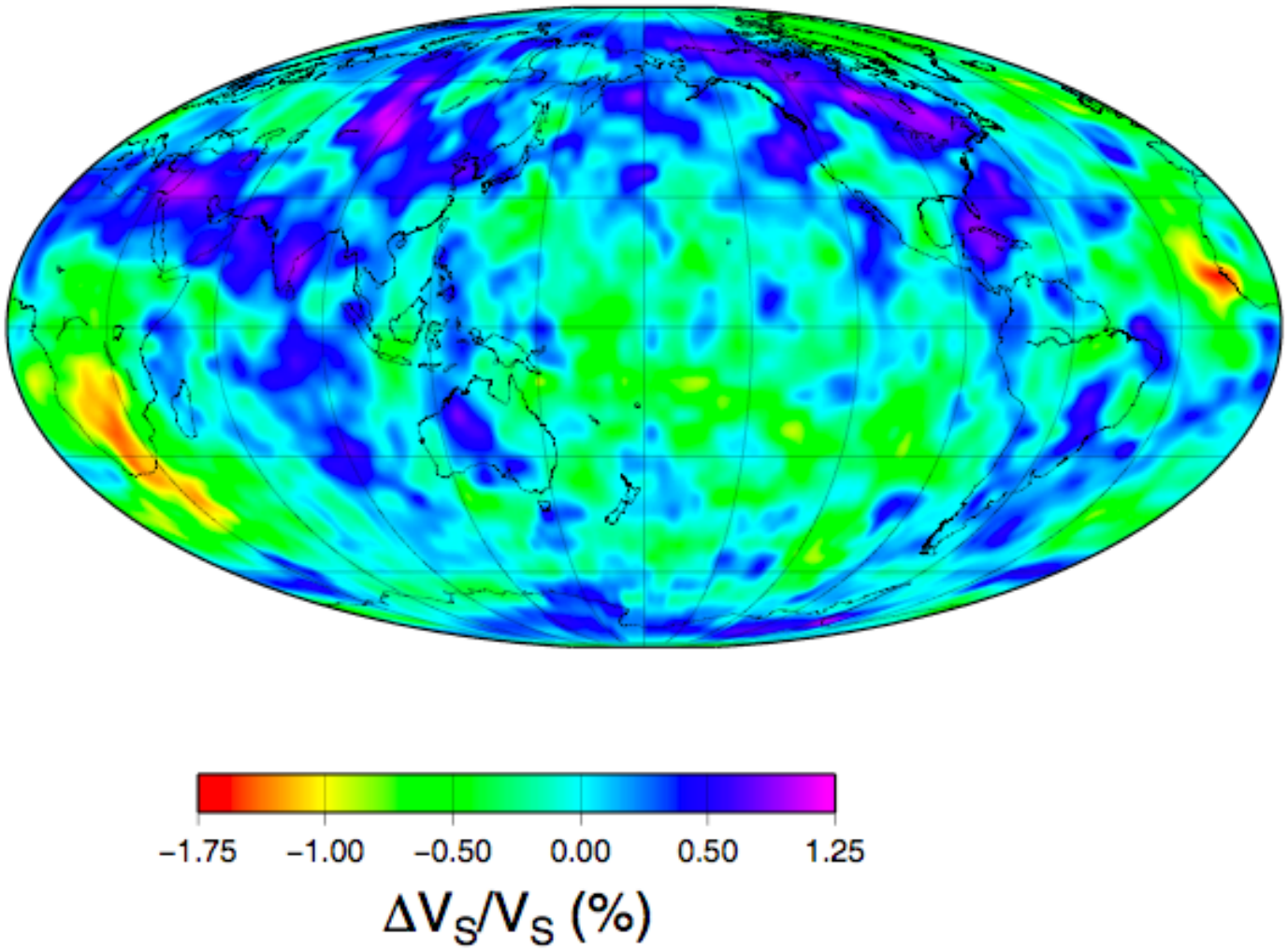


(1 gal = 1 cm s^{-2})

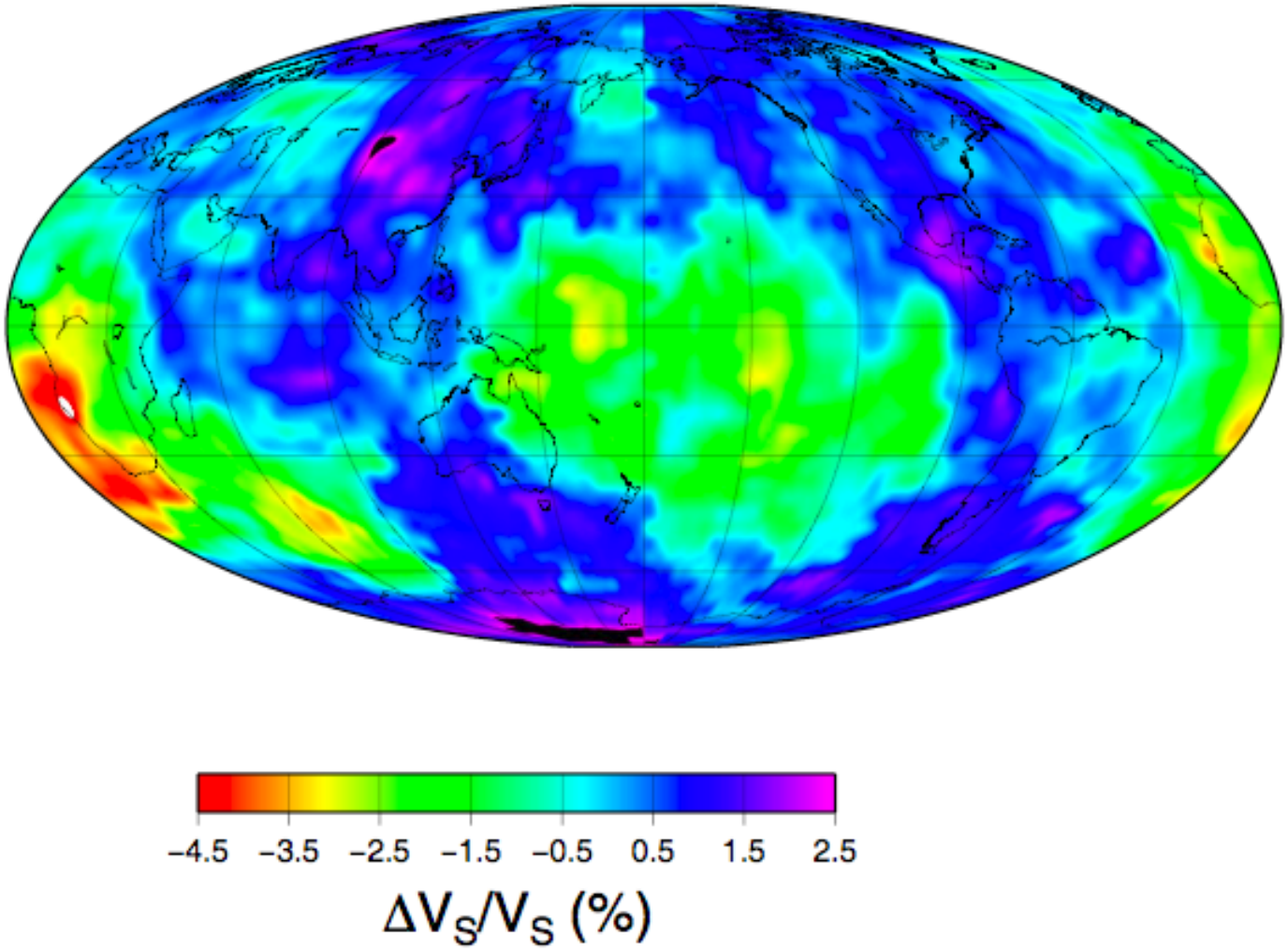
Seismic velocity anomalies @ 350 km depth



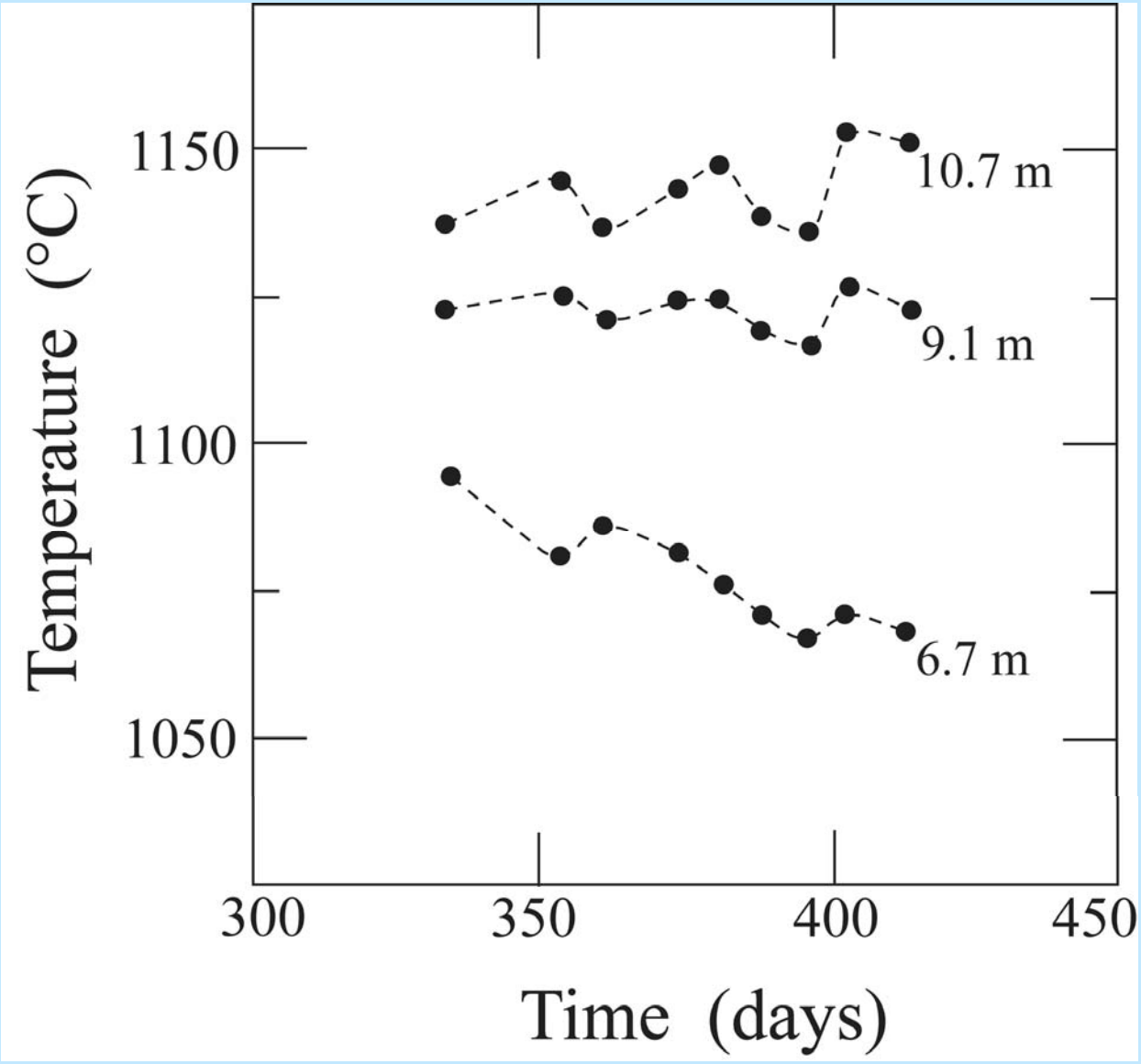
Seismic velocity anomalies @ 1810 km depth



Seismic velocity anomalies @ 2800 km depth

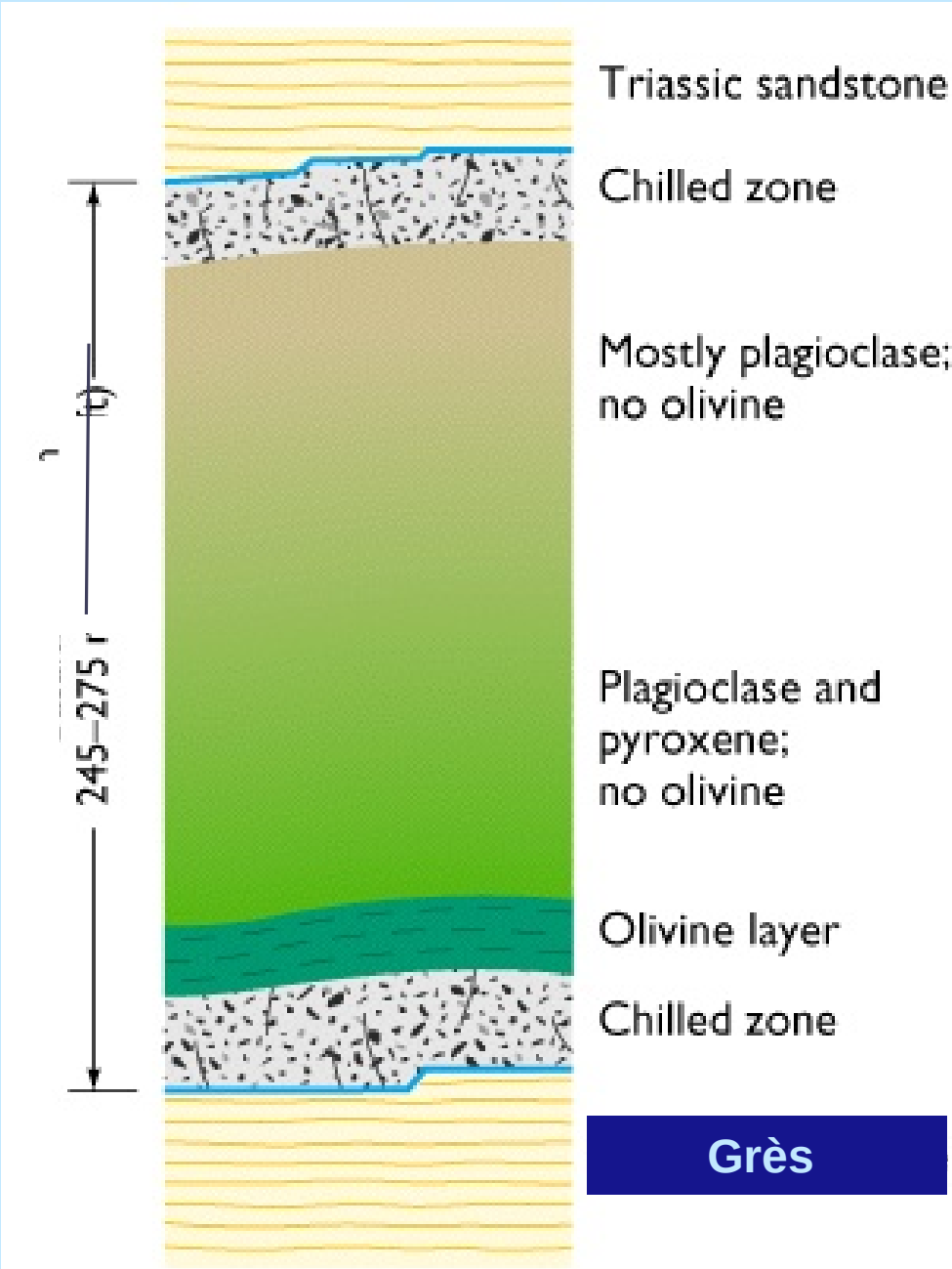


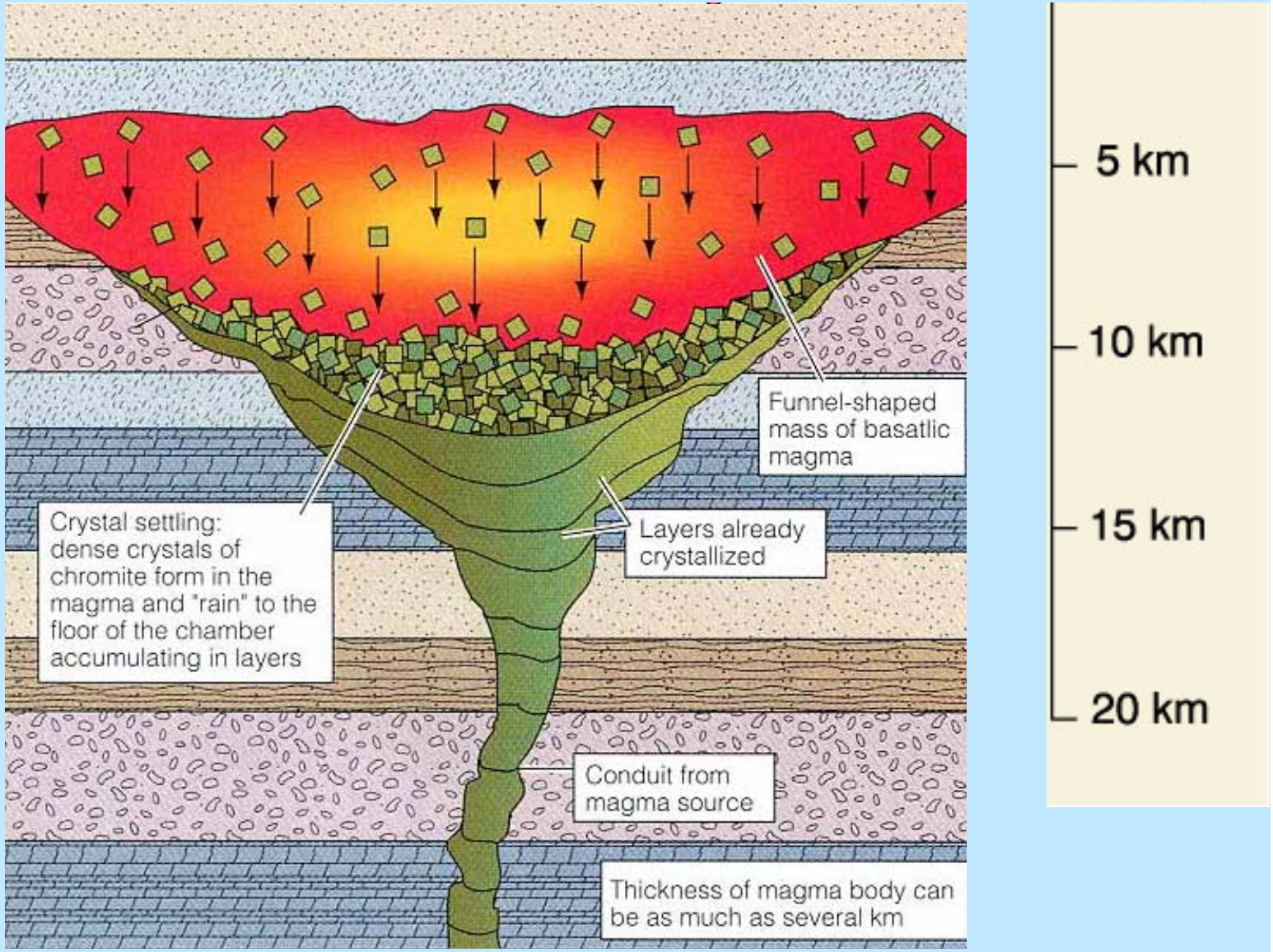
Erta-Ale, Ethiopia, lava lake


Temperature (°C)
1150
1100
1050
10.7 m
9.1 m
6.7 m
300
350
400
450
Time (days)

Palisades sill
(200 Ma, New Jersey)

(T_m = 1200° C)


Triassic sandstone
Chilled zone
Mostly plagioclase; no olivine
Plagioclase and pyroxene; no olivine
Olivine layer
Chilled zone
245–275 m
(b)
Grès


Funnel-shaped mass of basatlic magma
Crystal settling: dense crystals of chromite form in the magma and "rain" to the floor of the chamber accumulating in layers
Layers already crystallized
Conduit from magma source
Thickness of magma body can be as much as several km
5 km
10 km
15 km
20 km

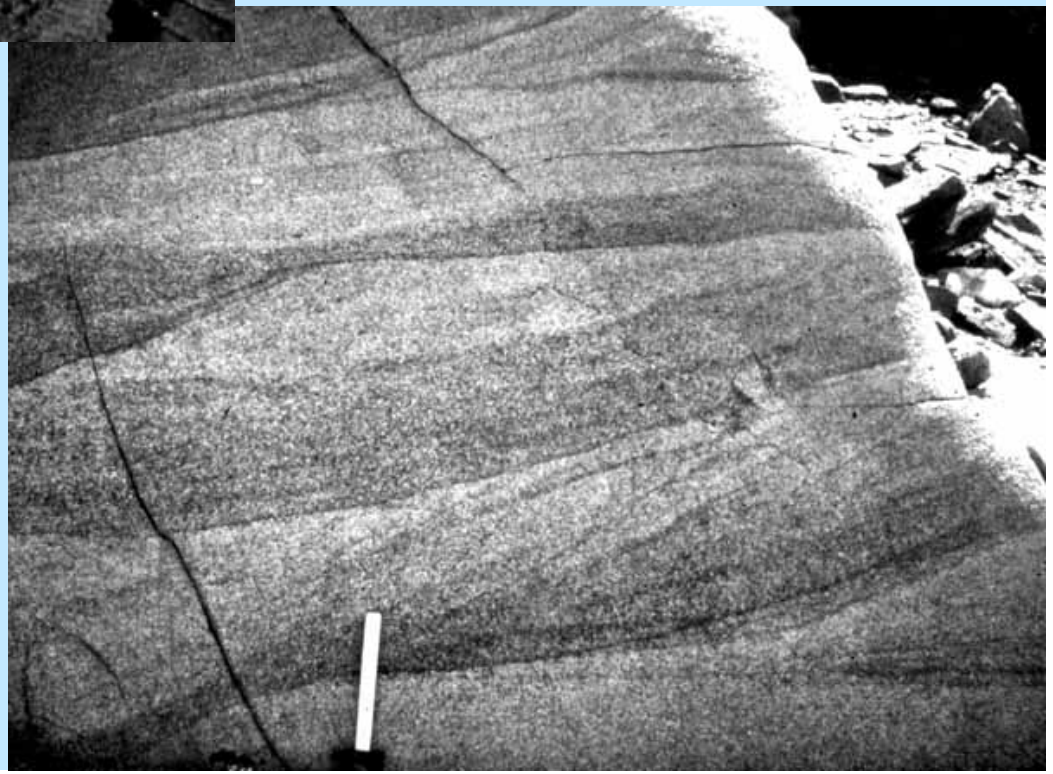
Four large mafic igneous intrusions

Name	Age (My)	Area (km^2)	Average thickness (km)
Stillwater, Montana, USA	2740	4,400	7
Bushveld, South Africa	2060	66,000	7–8 †
Duluth, Minnesota, USA	1096–1107 §	5,000	≈ 4 ‡
Dufek, Antarctica	182	6,600	7

† The intrusion is made of two different parts with different thicknesses.
§ Igneous activity occurred in several pulses over about 11 My.
‡ The intrusion is funnel-shaped and reaches at least 15 km thickness in its central part.

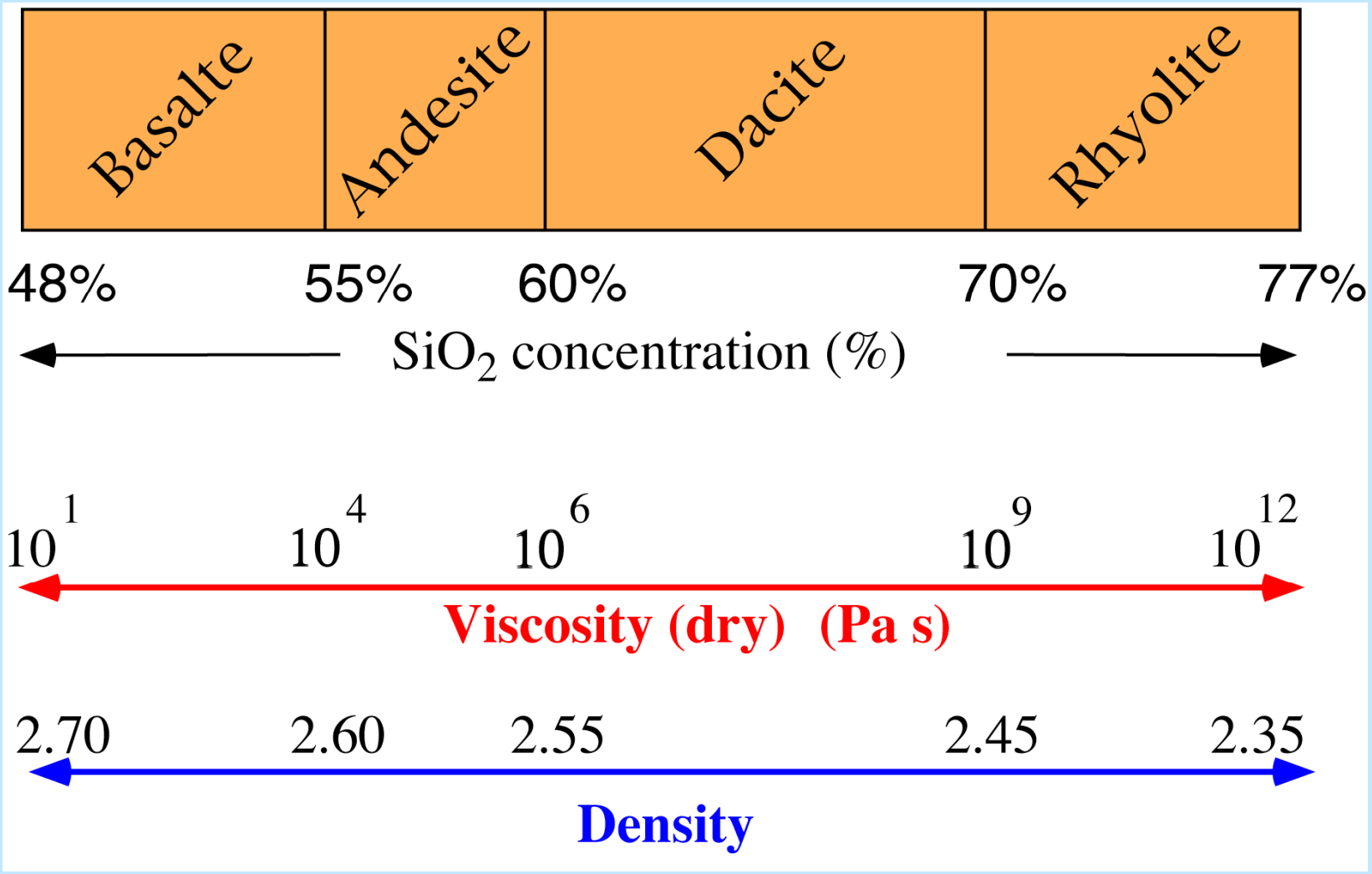
Cross-cutting

Discordant layering



SKAERGAARD (Groenland)

MAGMAS : A WIDE RANGE OF PHYSICAL PROPERTIES



Physical characteristics of geological convective systems

System	h	ΔT, K	μ, Pa s	Pr	Ra
Upper mantle	660 km	1300 †	5×10^{20}	10^{23}	10^{6}
Whole mantle	3000 km	3300 †	5×10^{21}	10^{24}	10^{7}
Basaltic lava lake	50 m	50 ‡	10	10^{3}	10^{12}
Basaltic magma reservoir	1 km	50 ‡	10	10^{3}	10^{16}
Dacitic magma reservoir	1 km	50 ‡	10^{6}	10^{8}	10^{11}

Values have been rounded off for clarity.
† True temperature difference deduced from the mantle geotherm of Figure 2.4.
‡ temperature difference across the actively convecting part of the system.

Tonga 2009

RABAUL (New Guinea) 1994

RABAUL
(New Guinea)
1994