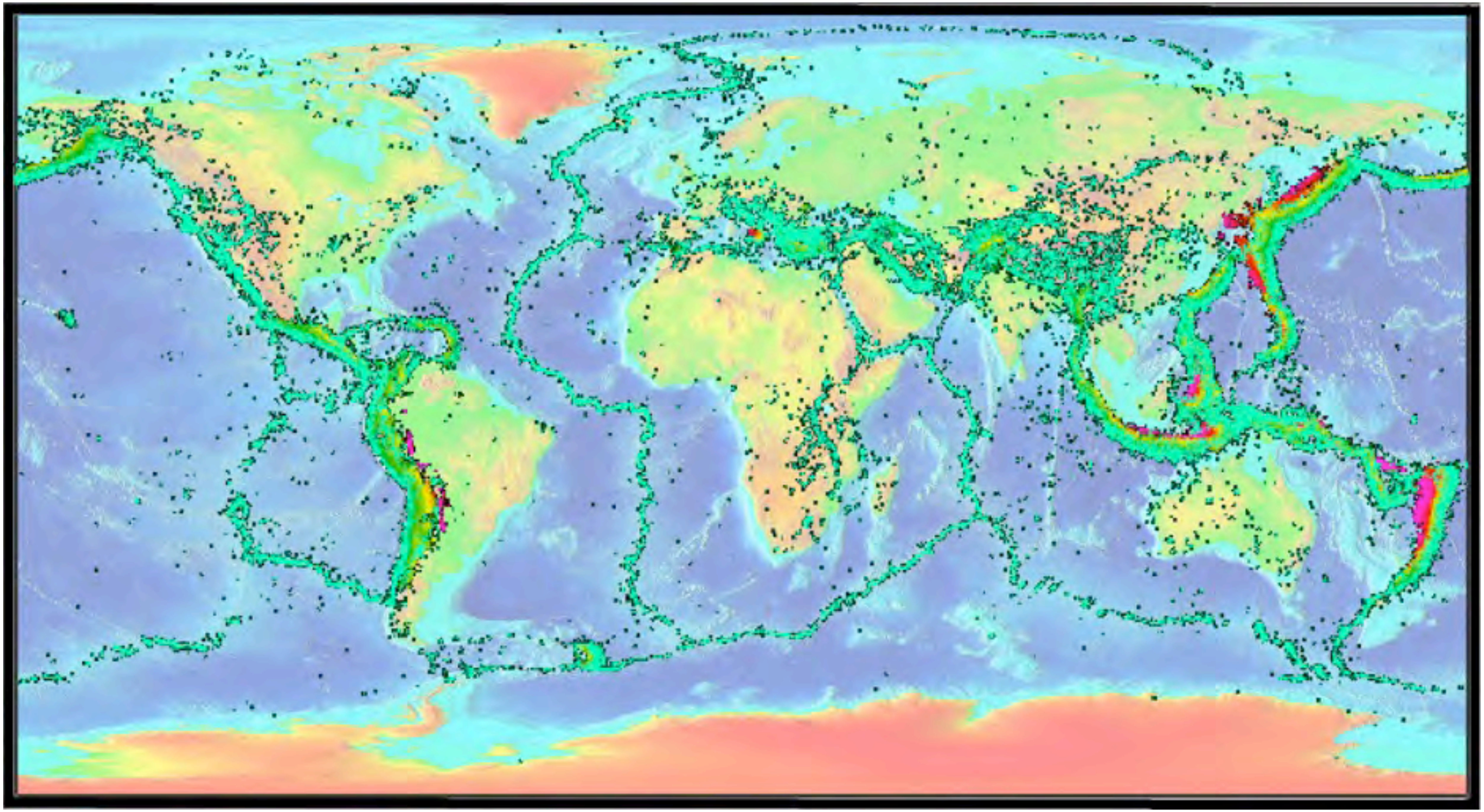
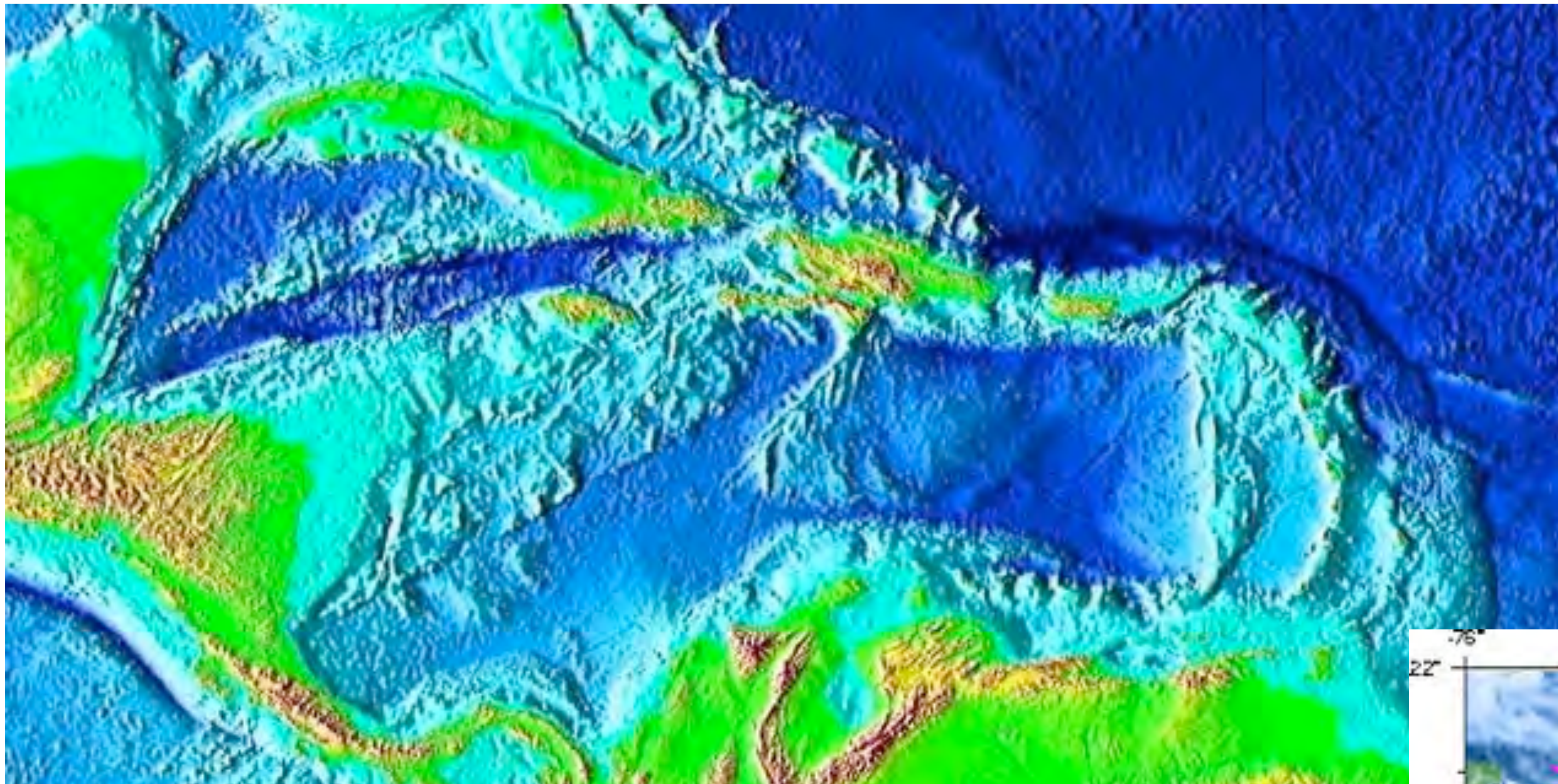
11-
Subduktion zonen

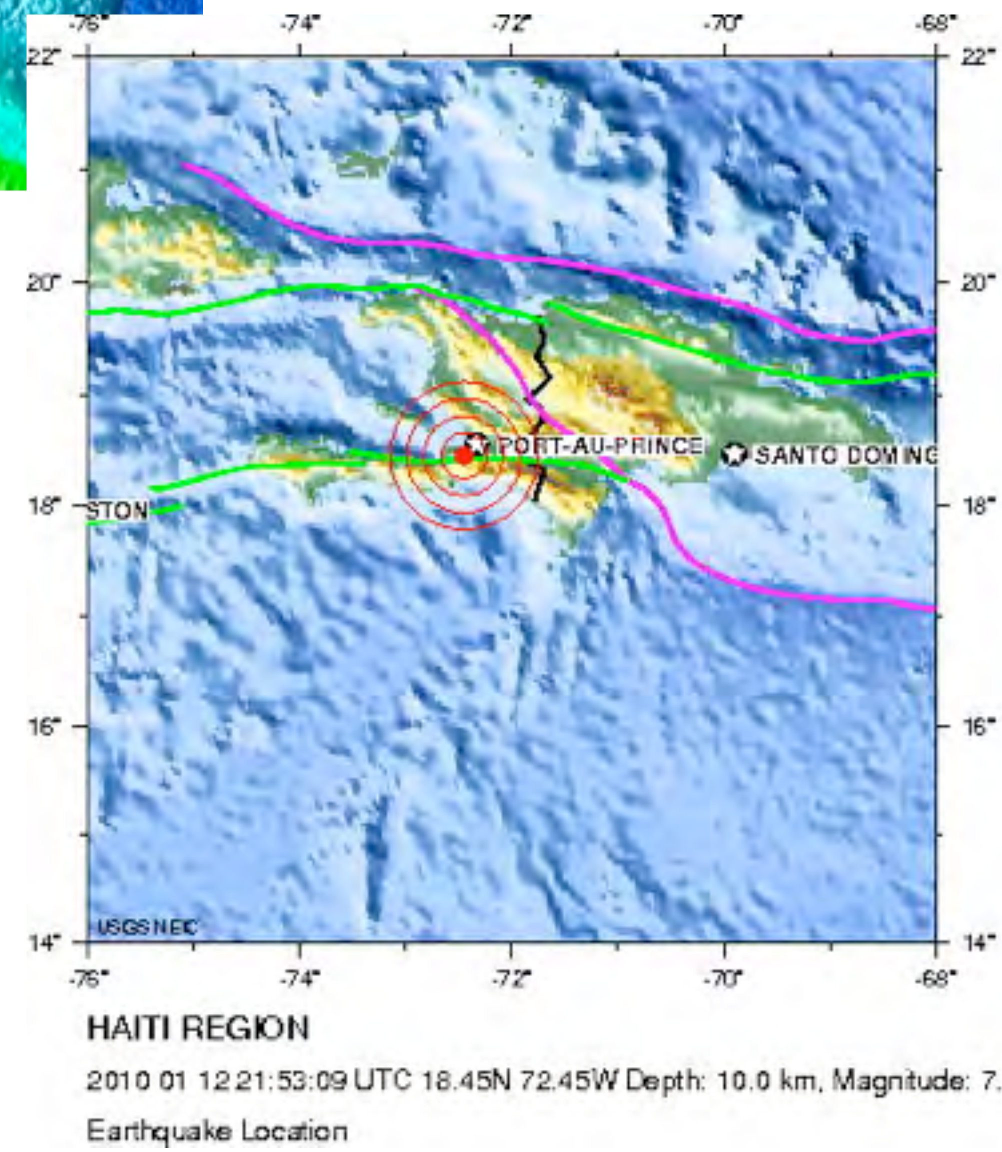
Earthquakes



Haiti Earthquake 12.01.2010

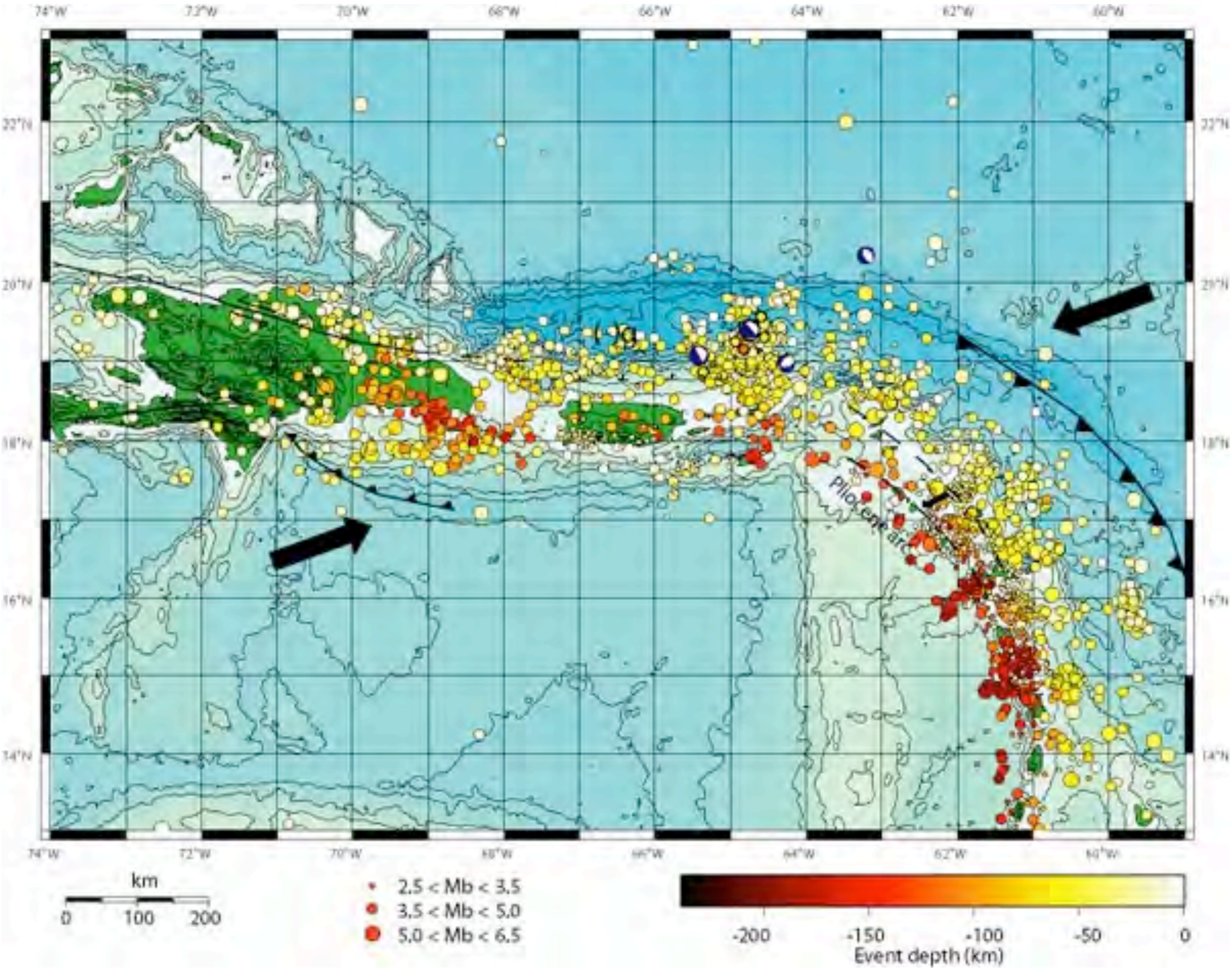


USGS

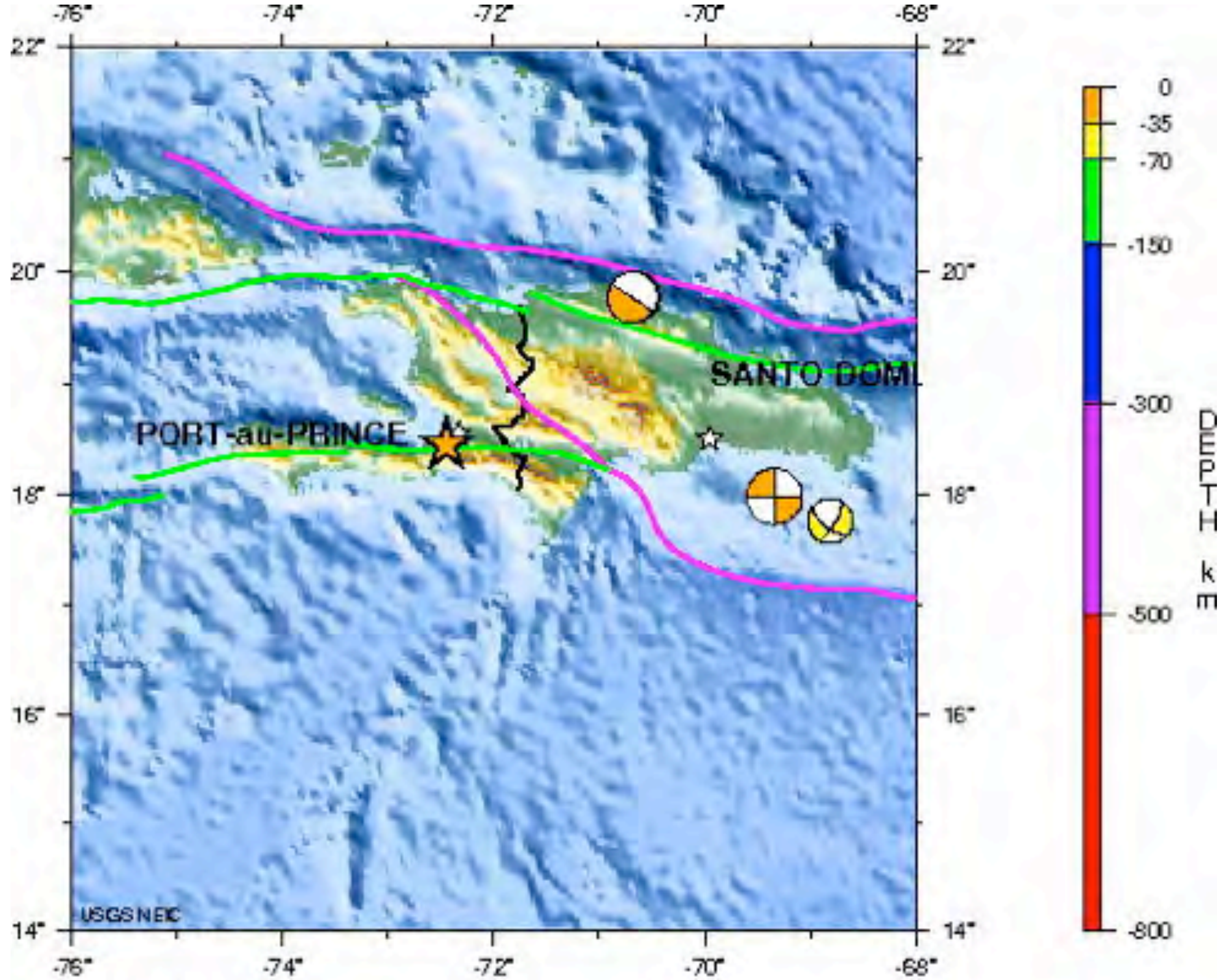


Haiti Earthquake 12.01.2010

USGS



Haiti Earthquake 12.01.2010



MMI	Mag	Time and Location	Latitude	Longitude	Depth
VIII	5.7	2010-01-13 05:02:58 HAITI REGION	18.42° N	72.94° W	10km
VII	5.5	2010-01-13 01:36:31 HAITI REGION	18.36° N	72.83° W	10km
VII	5.5	2010-01-12 22:12:05 HAITI REGION	18.48° N	72.56° W	10km
VIII	5.9	2010-01-12 22:00:42 HAITI REGION	18.32° N	72.85° W	10km
X	7.0	2010-01-12 21:53:09 HAITI REGION	18.45° N	72.45° W	10km

USGS

http://earthquake.usgs.gov/

Haiti Earthquake 12.01.2010

USGS Centroid Moment Tensor Solution

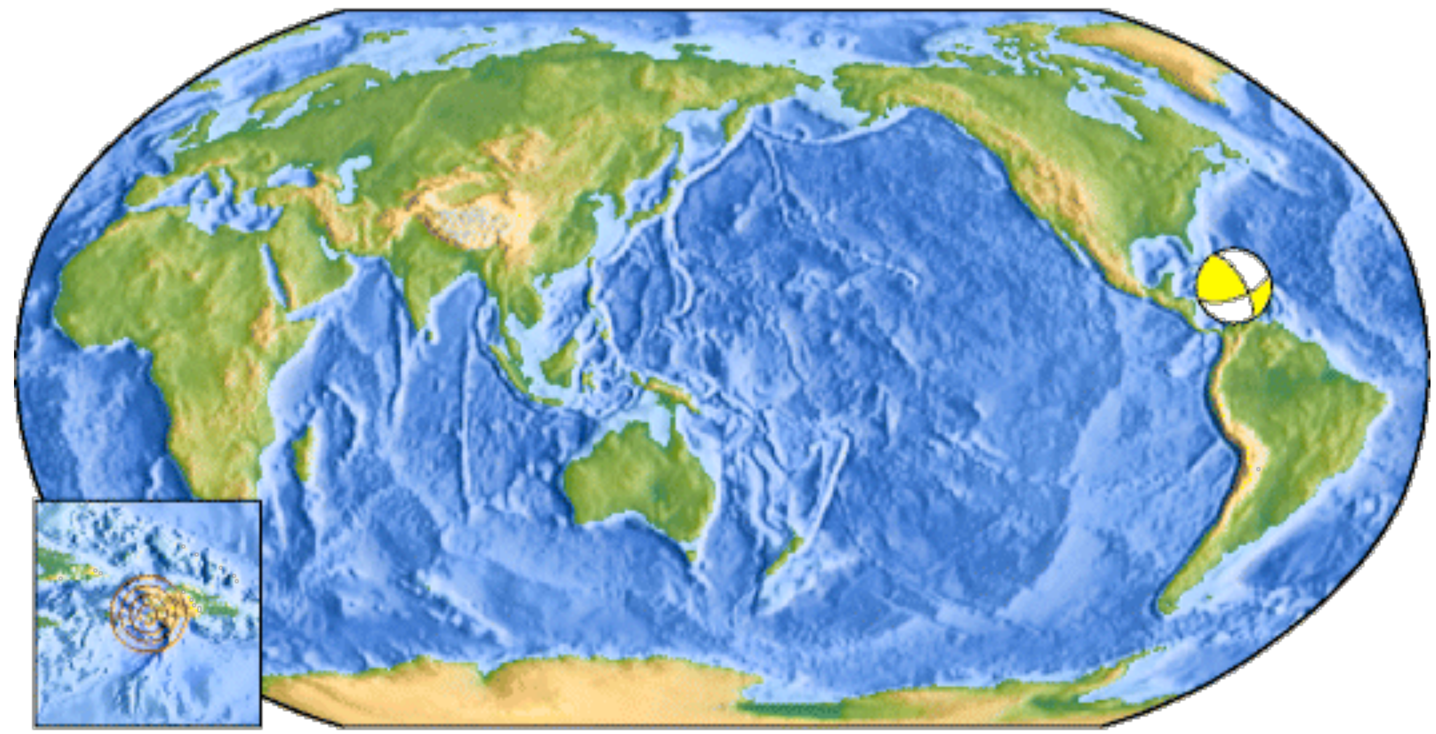
```
10/01/12 21:53:10.16
HAITI REGION
Epicenter:  18.523  -72.559
MW 7.0

USGS CENTROID MOMENT TENSOR
10/01/12 21:53:24.50
Centroid:    18.826  -72.162
Depth  10           No. of sta:125
Moment Tensor;    Scale 10**19 Nm
  Mrr= 1.63         Mtt=-3.71
  Mpp= 2.08         Mrt= 0.42
  Mrp= 1.93         Mtp= 2.50
 Principal axes:
  T  Val=   4.40  Plg=35  Azm=289
  N         0.26      54      115
  P        -4.65       2       21

Best Double Couple:Mo=4.5*10**19
 NP1:Strike= 71 Dip=64 Slip=  25
 NP2:        330     68       151

              -------
         ------------- P -
       #####----------   ---
     #########----------------
   #############---------------
  ##############----------------
  ####   ##########--------------
 ##### T ###########-----------##
 #####   ############---------####
 #####################------######
 ######################--#########
 #####################--##########
  ##############---------########
  -----------------------########
   -----------------------######
     ---------------------####
       -------------------##
         -----------------
              -------
```

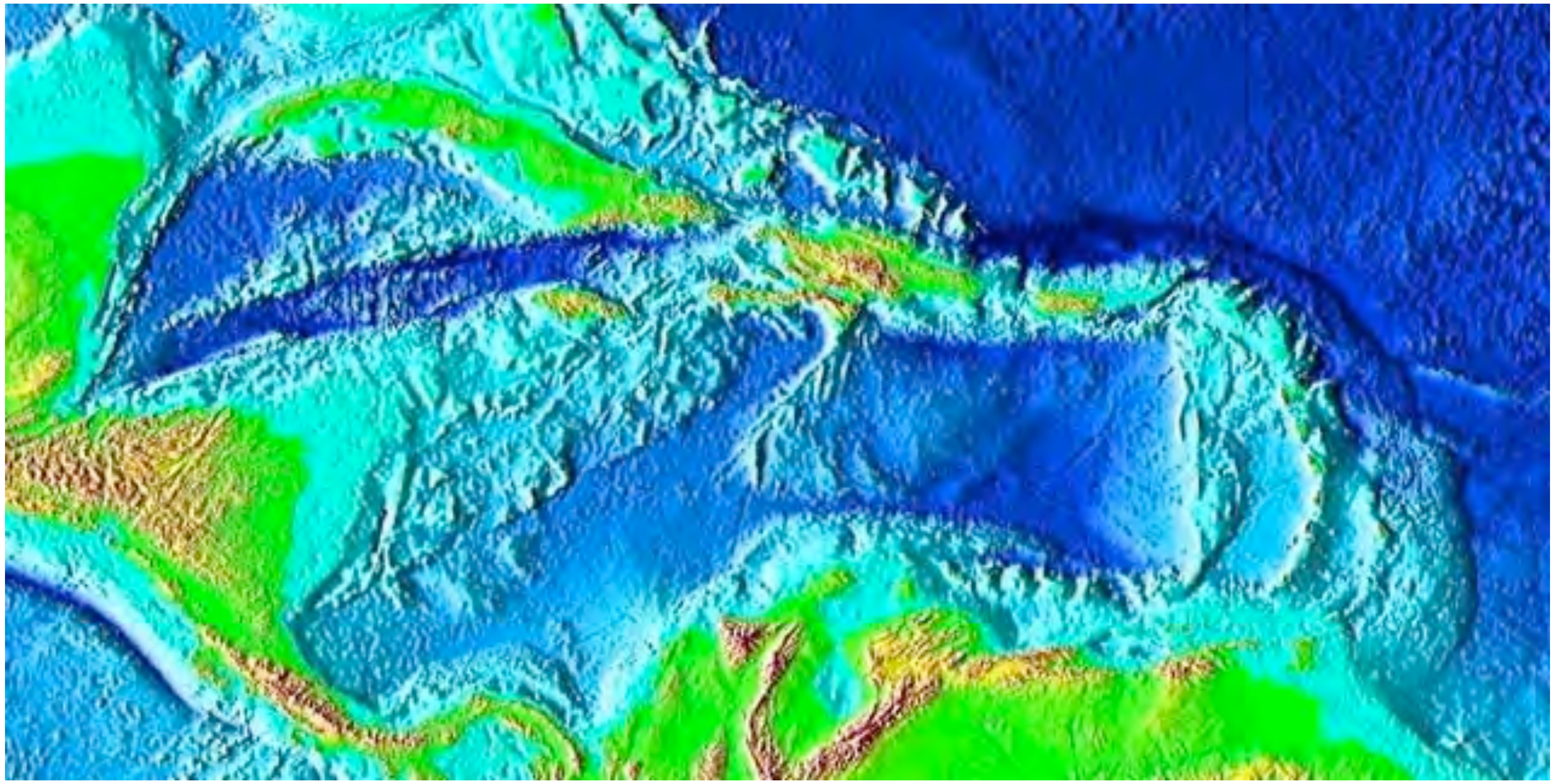
HAITI REGION
Mw 7.0
USGS Centroid Moment Tensor Solution

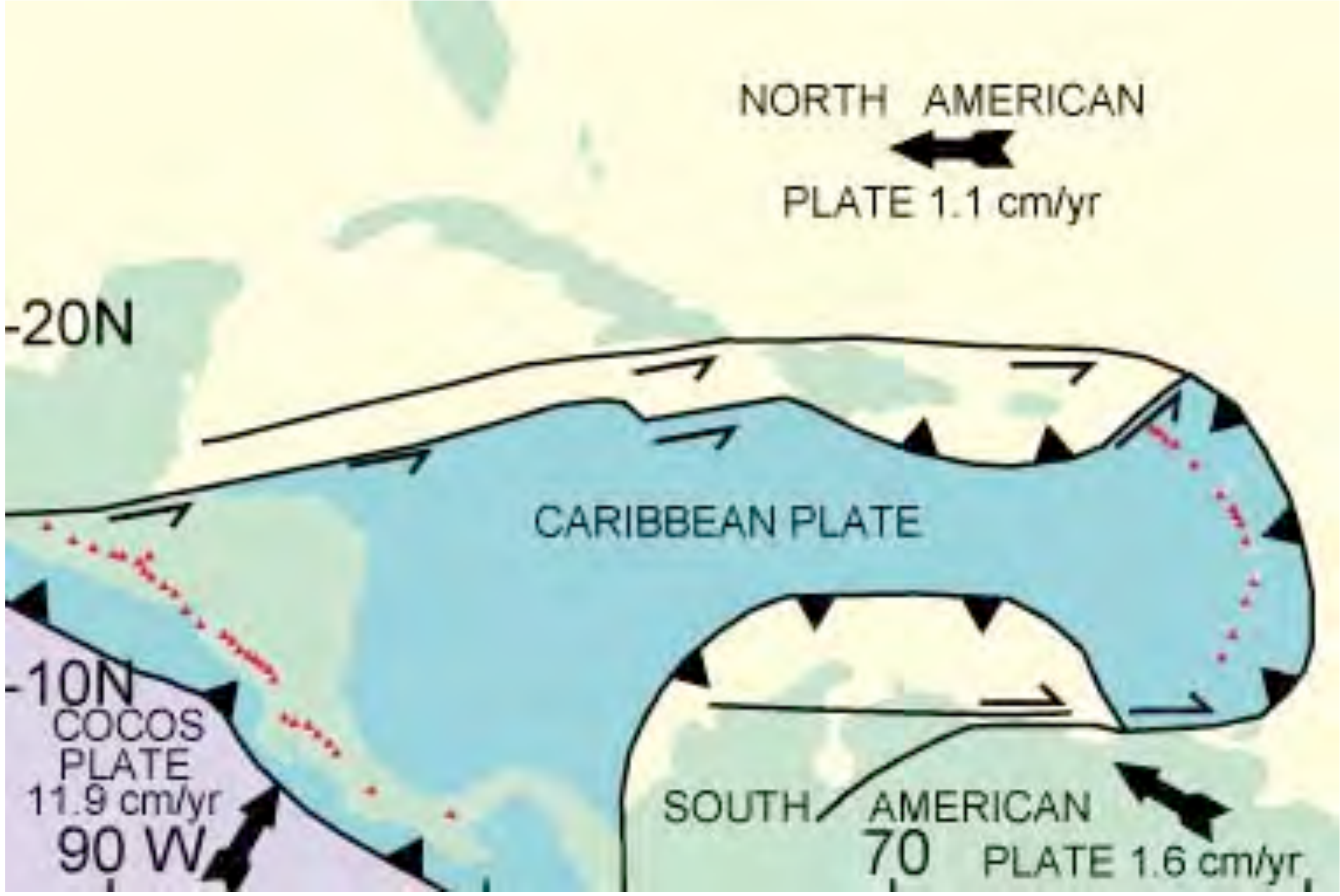


Date: 12 JAN 2010
Time: 21:53:10.16
Epicenter: 18.523 -72.559
Depth: 10 km

USGS

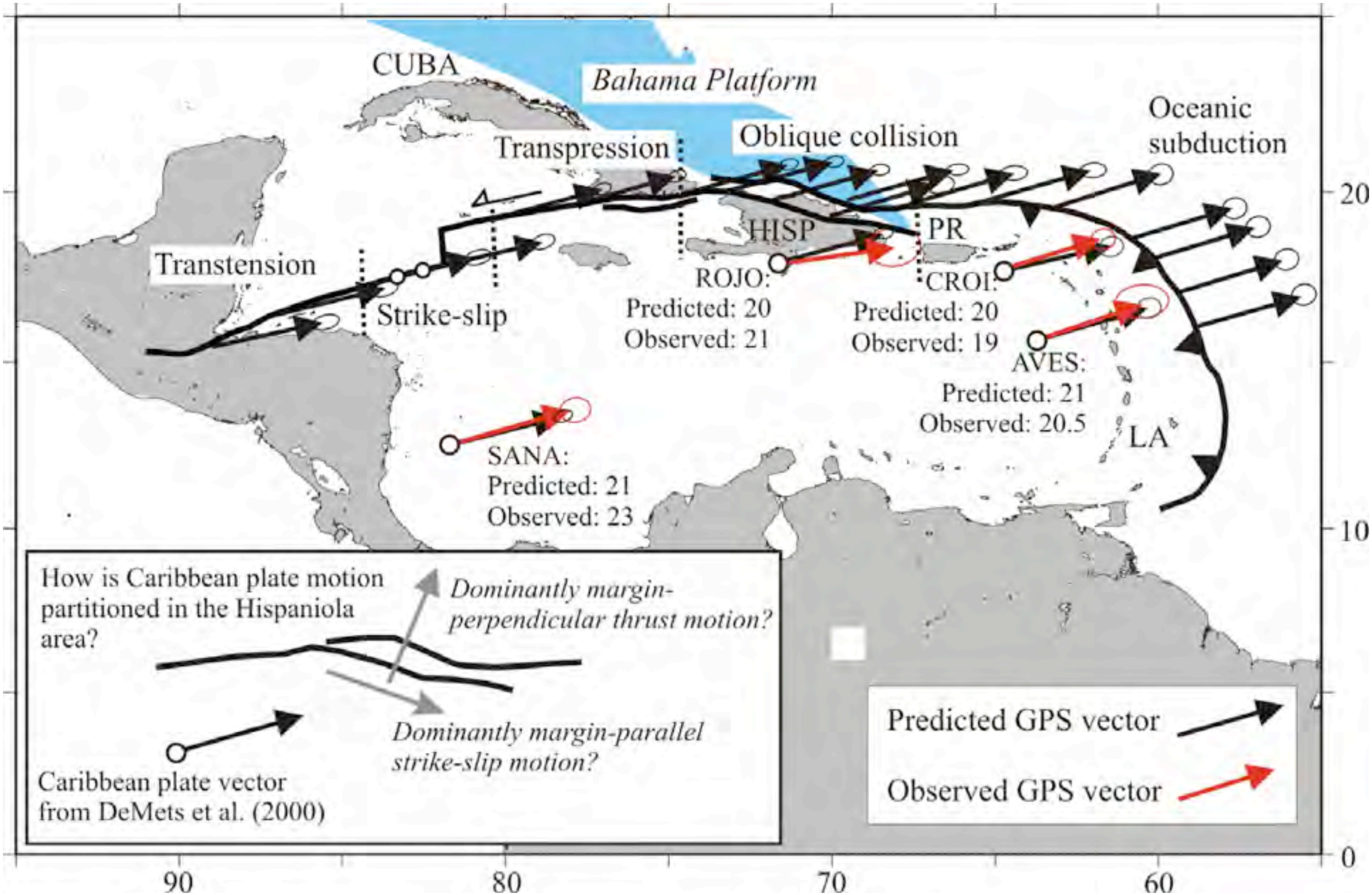
Haiti Earthquake 12.01.2010





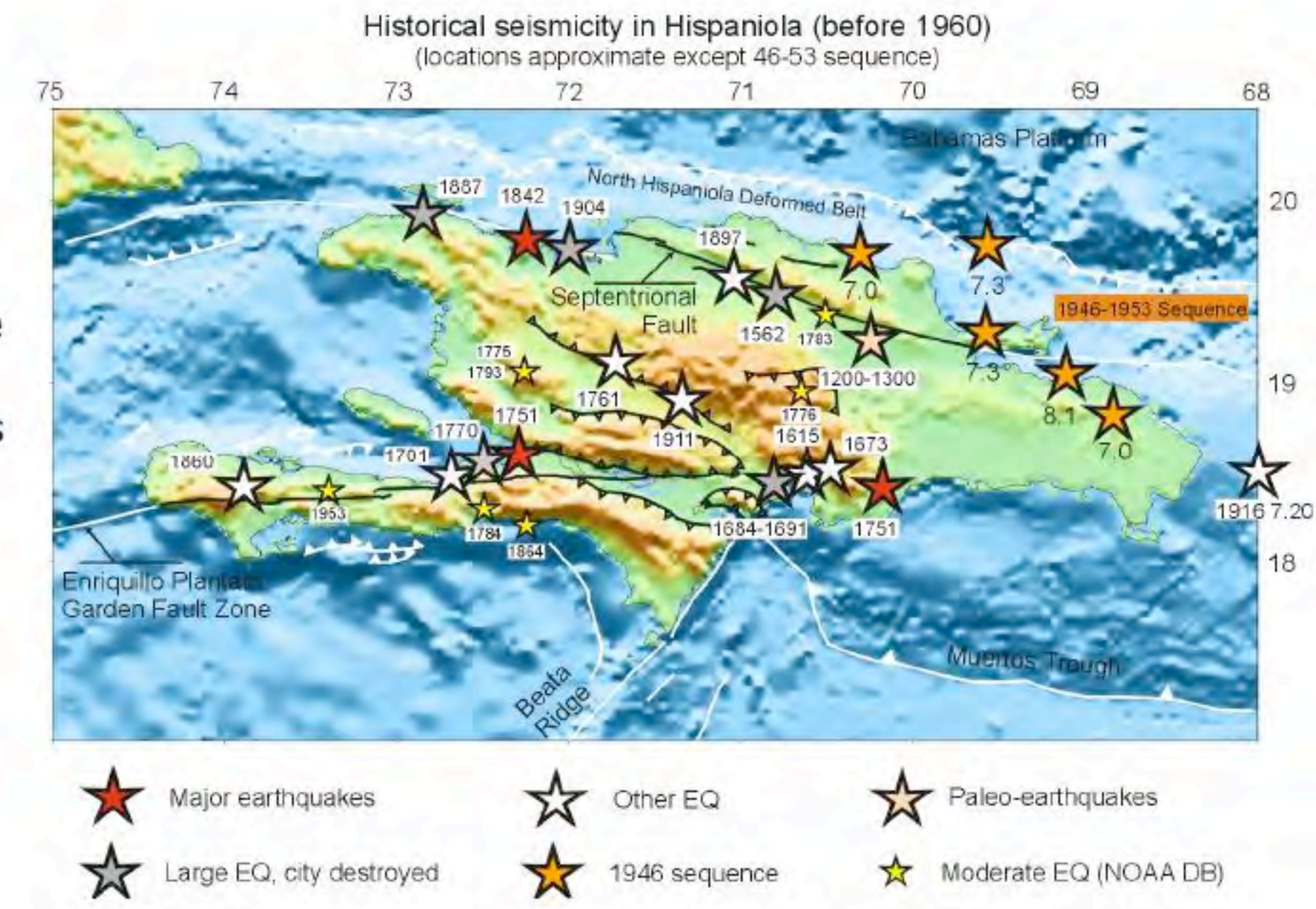
R. Bousquet 2009-2010

Haiti Earthquake 12.01.2010



Calais, RENASS

Haiti Earthquake 12.01.2010

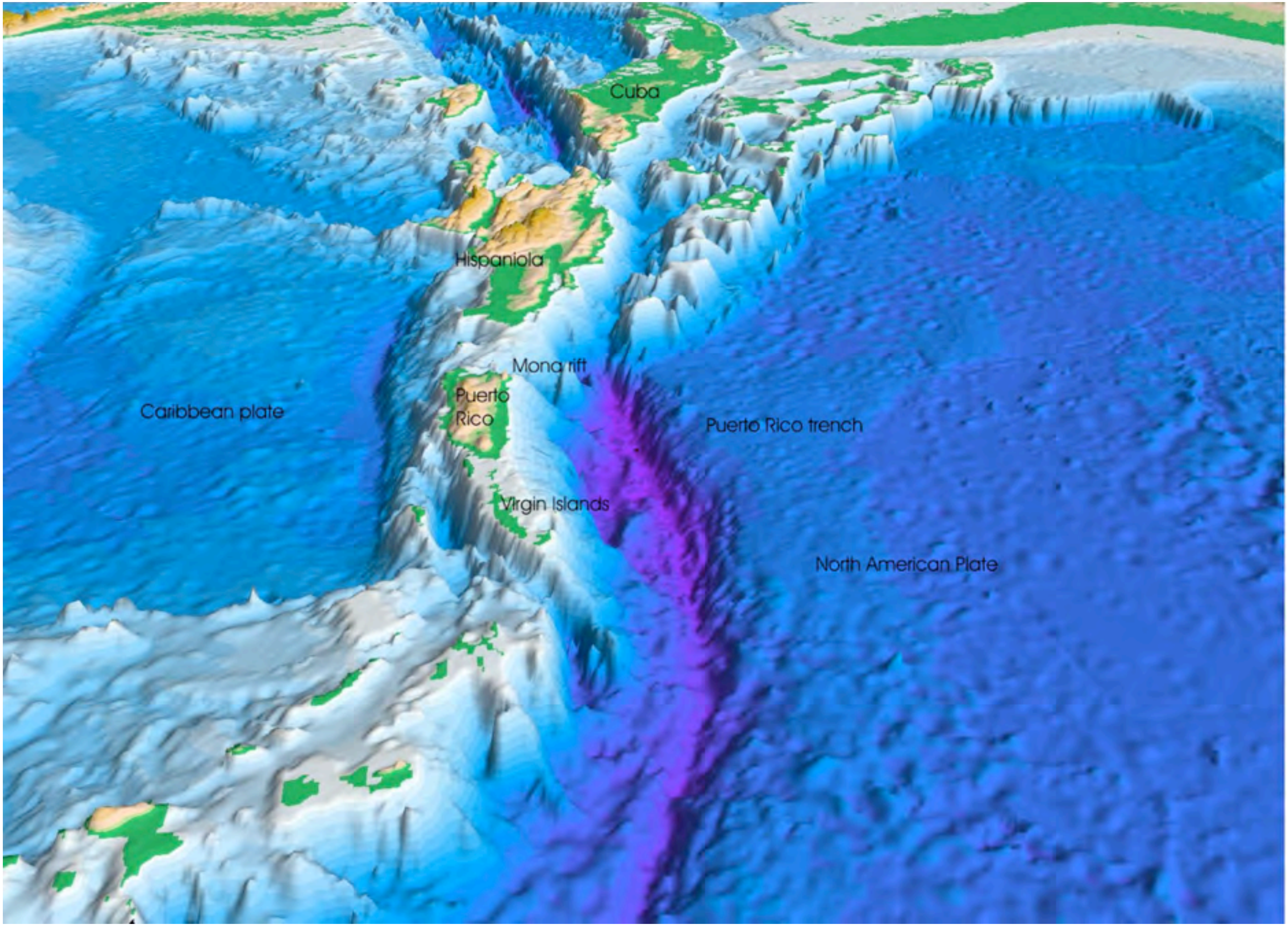


RENASS

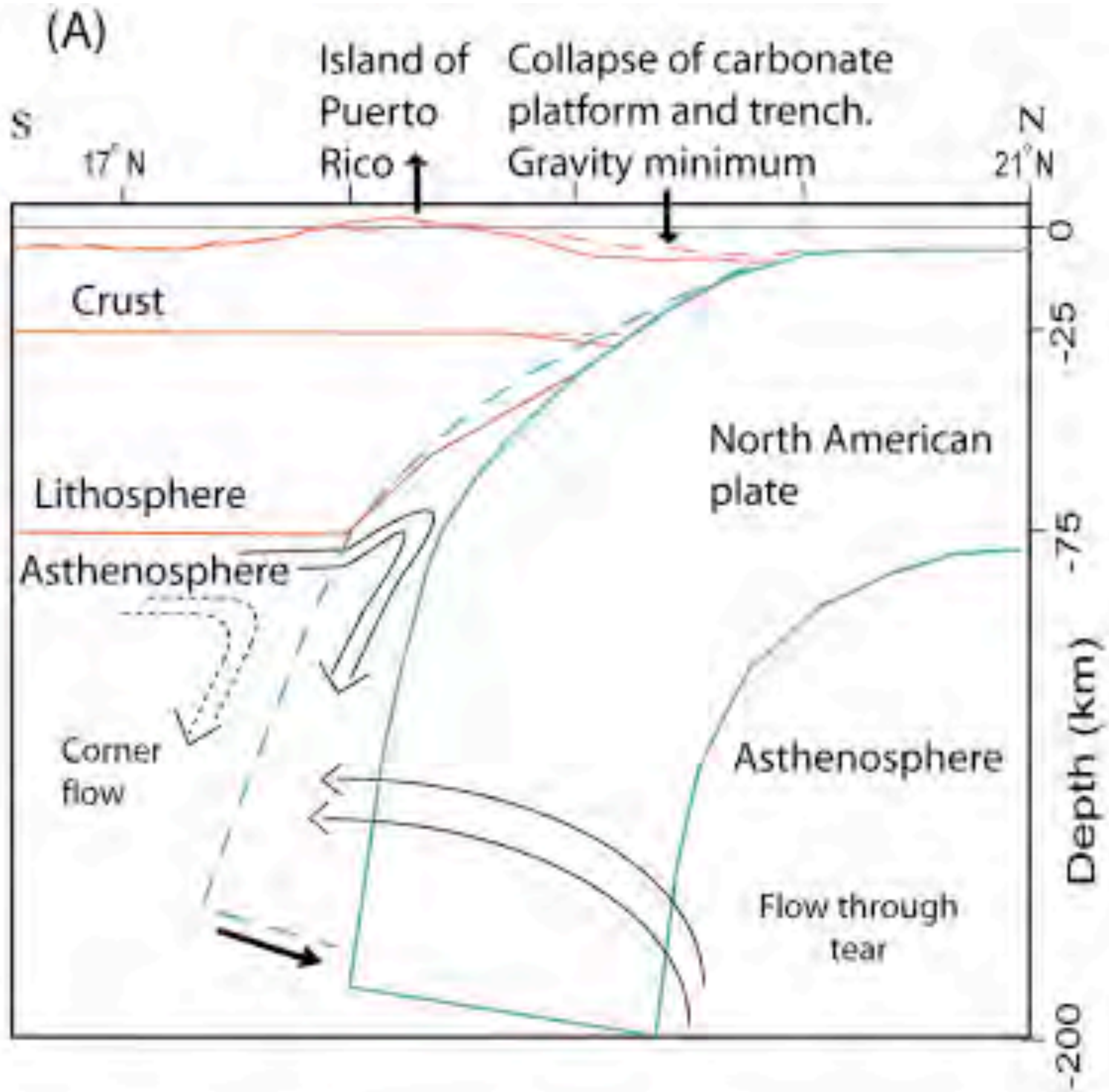
R. Bousquet 2009-2010

Haiti Earthquake 12.01.2010

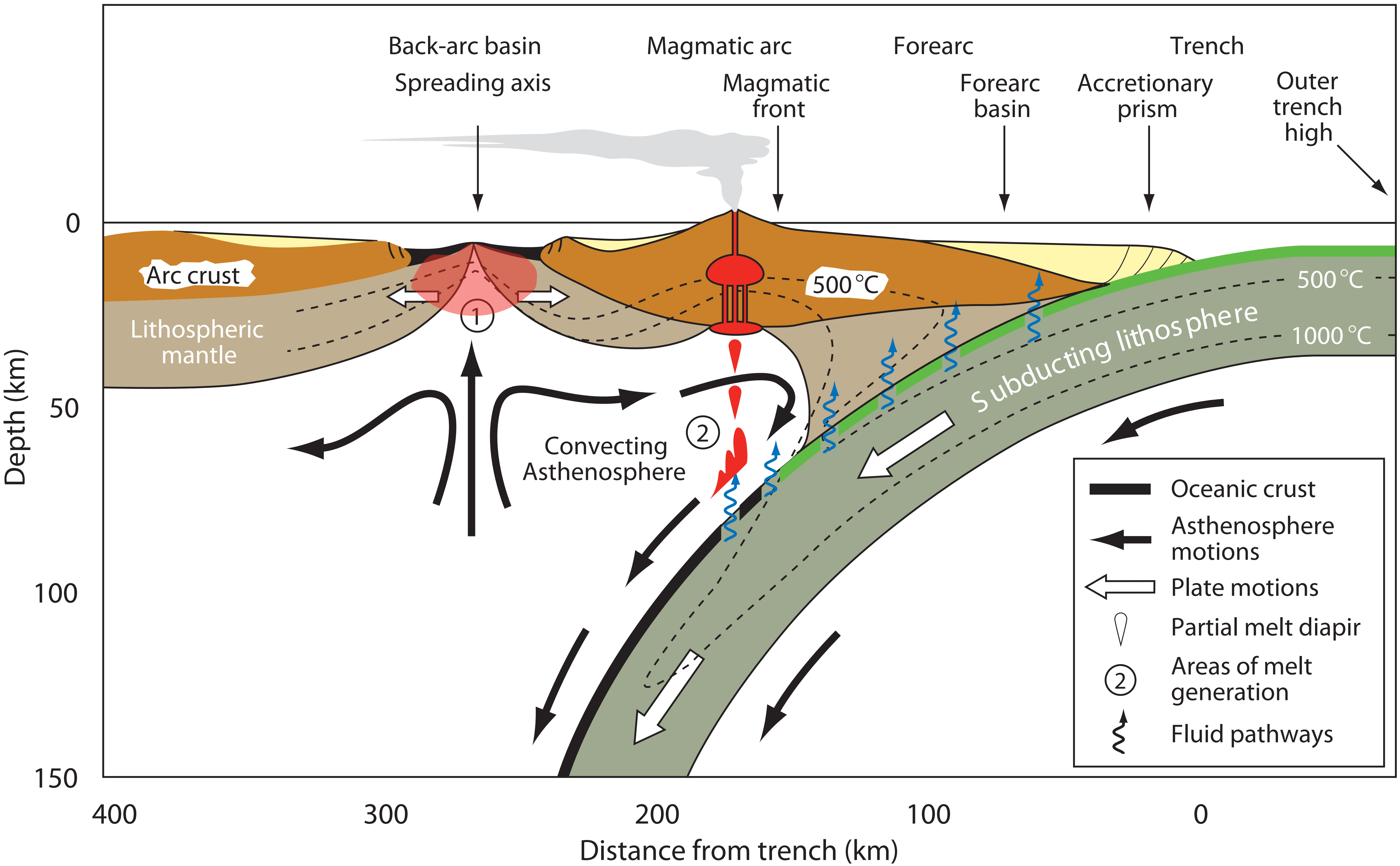
Woods Hole



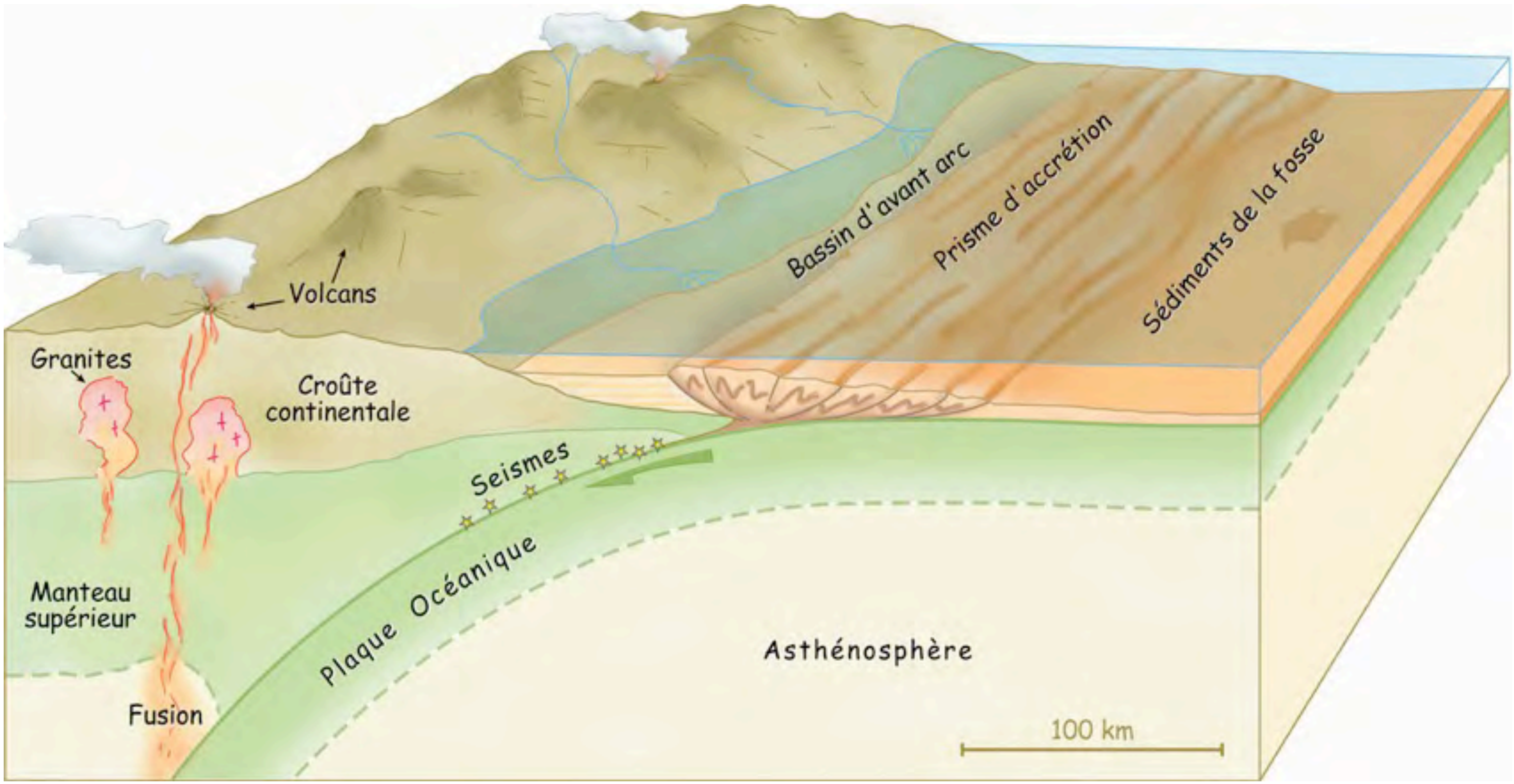
Haiti Earthquake 12.01.2010



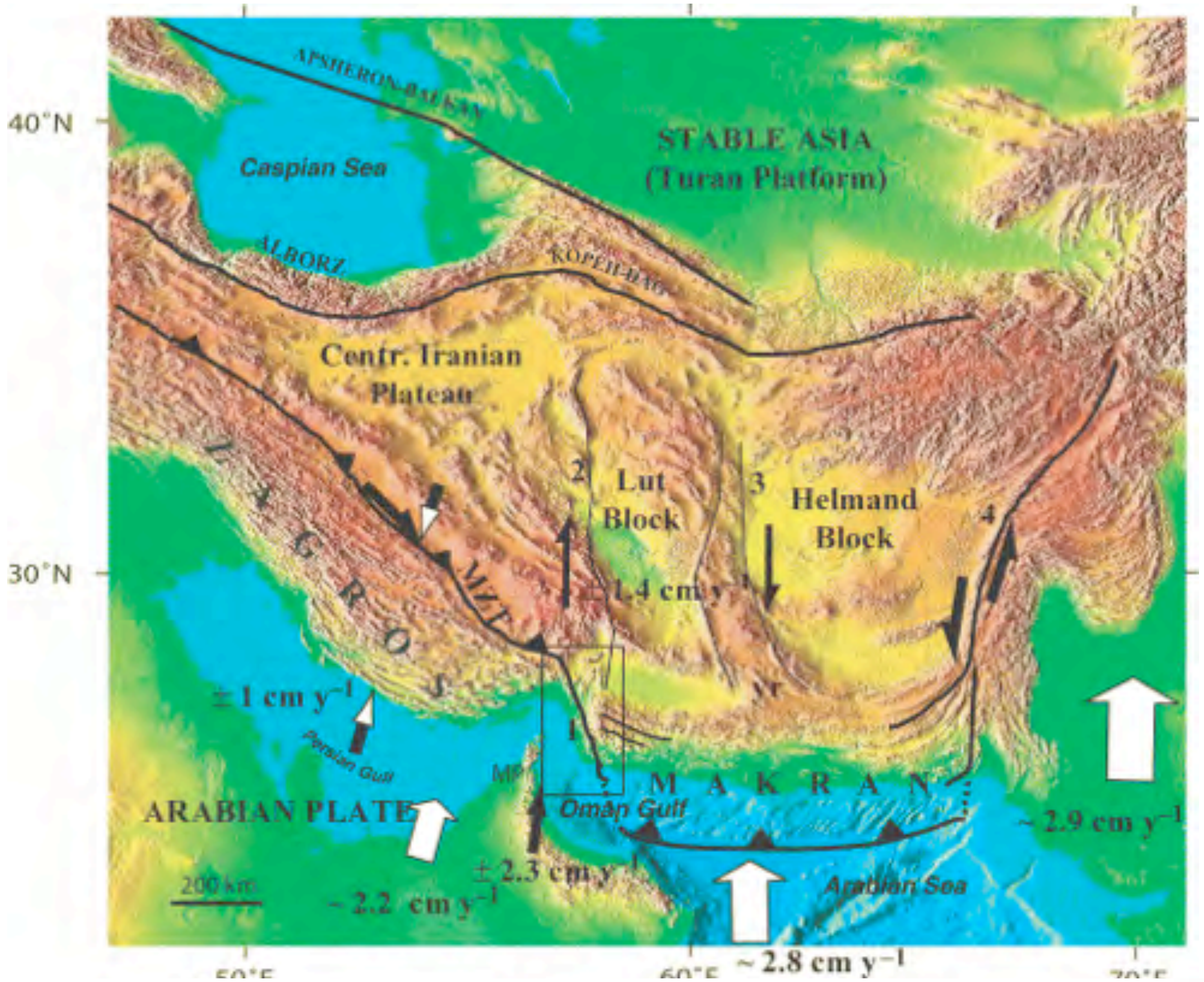
USGS


Back-arc basin
Spreading axis
Magmatic arc
Magmatic front
Forearc
Forearc basin
Trench
Accretionary prism
Outer trench high
0
50
100
150
Depth (km)
Arc crust
Lithospheric mantle
500 °C
1000 °C
Subducting lithosphere
Convecting Asthenosphere
1
2
400
300
200
100
0
Distance from trench (km)
Oceanic crust
Asthenosphere motions
Plate motions
Partial melt diapir
Areas of melt generation
Fluid pathways

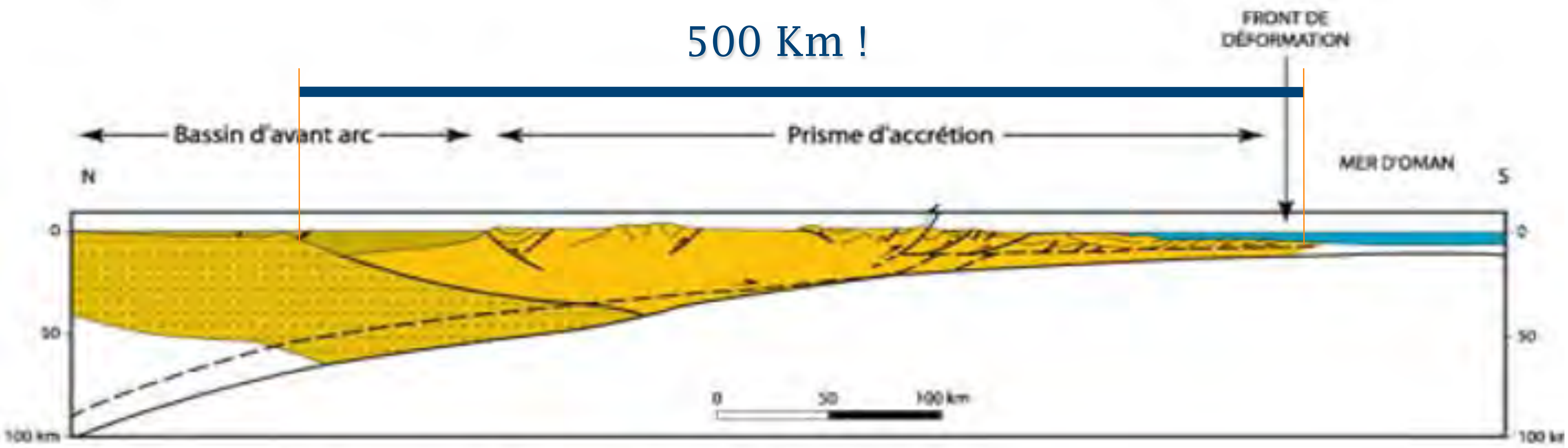
An accretionary wedge is a wide submarine mountain belt…



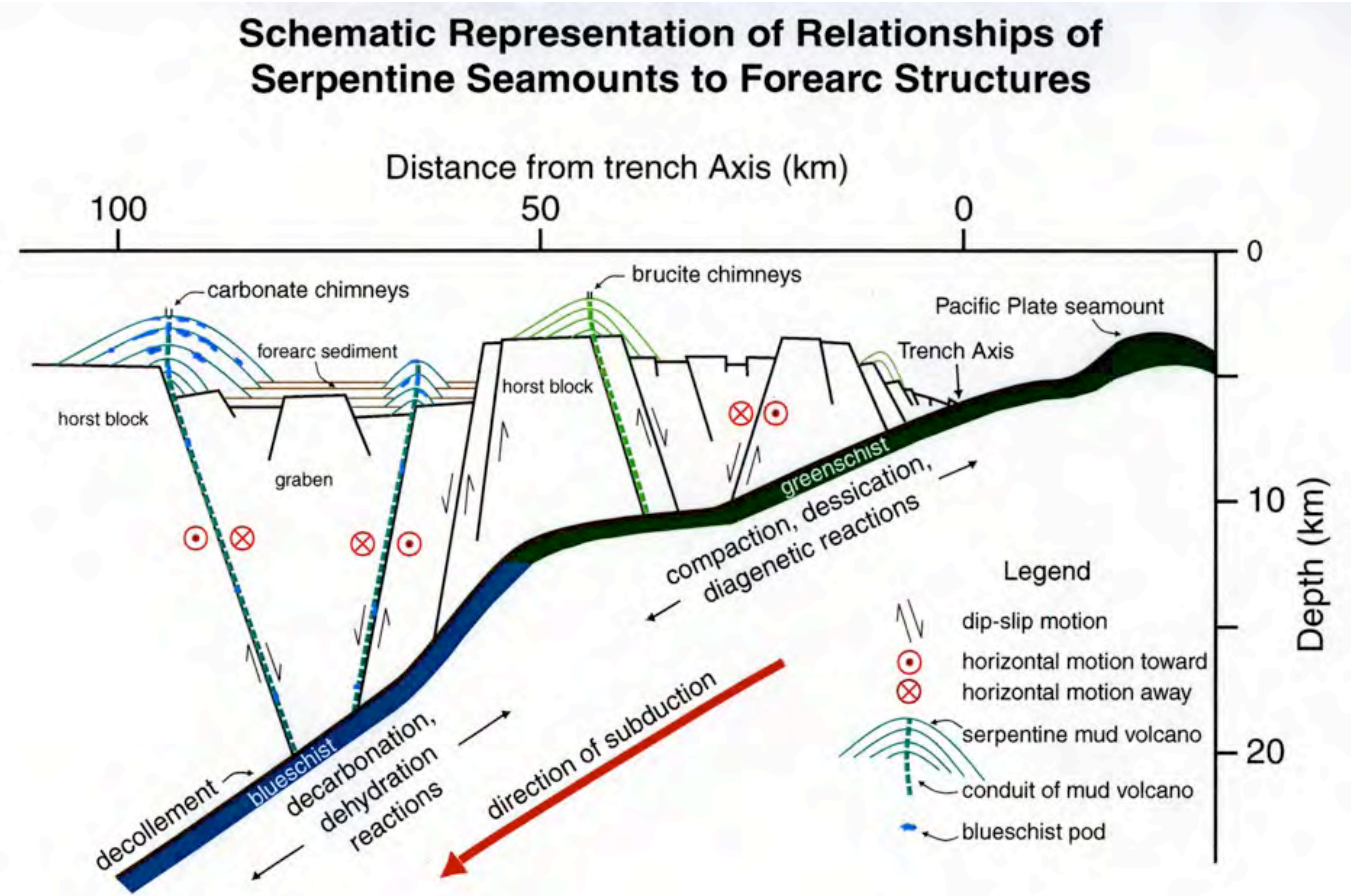
Makran wedge



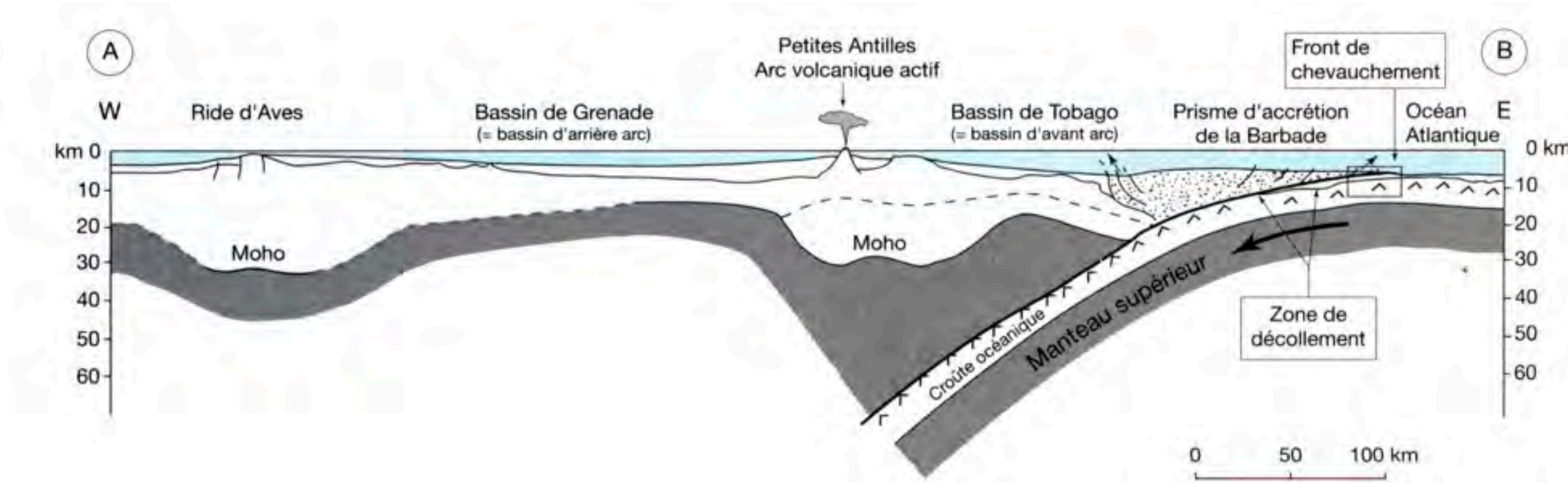
500 Km !



Marianna wedge

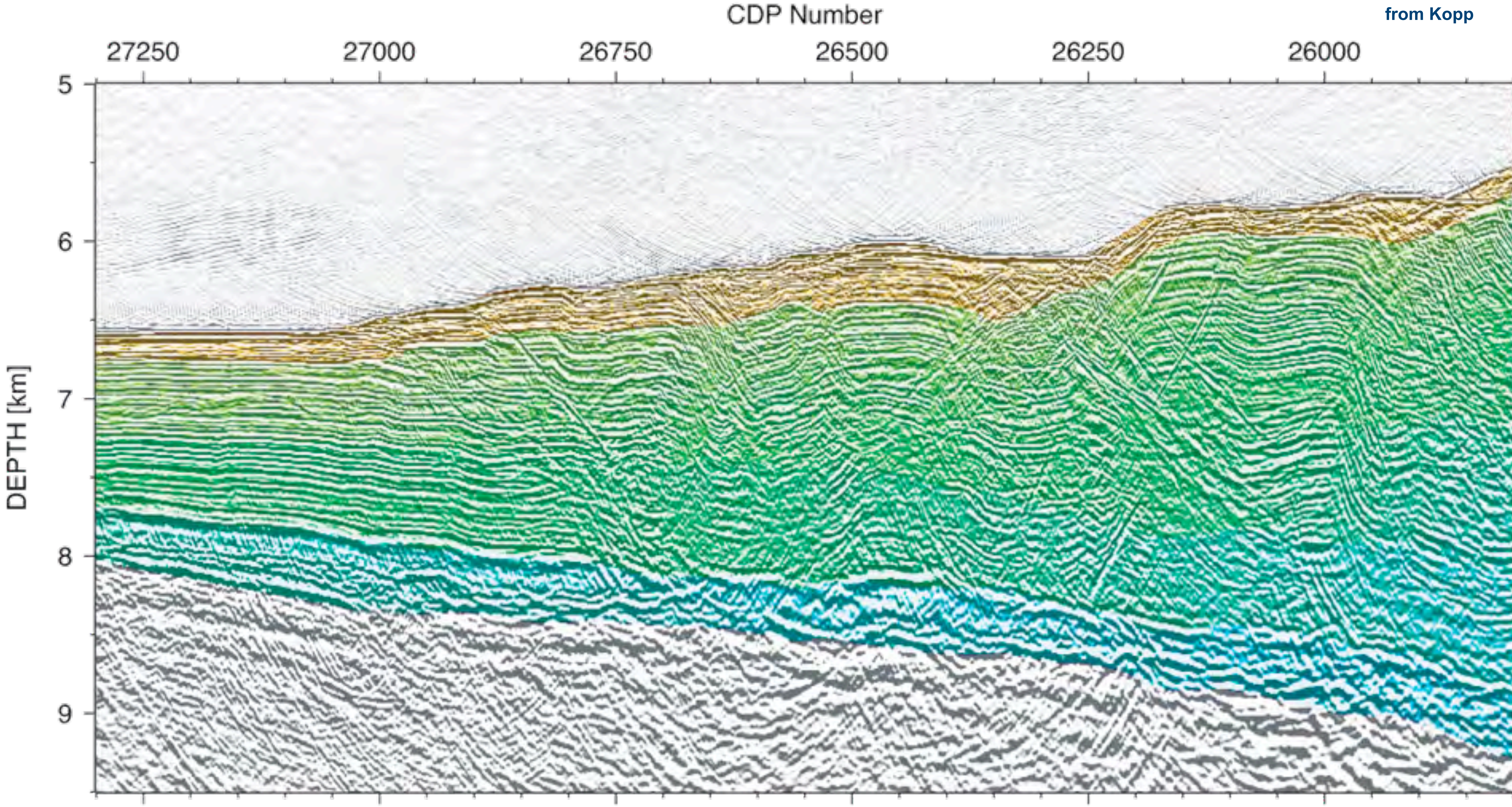


Lesser Antilles wedge



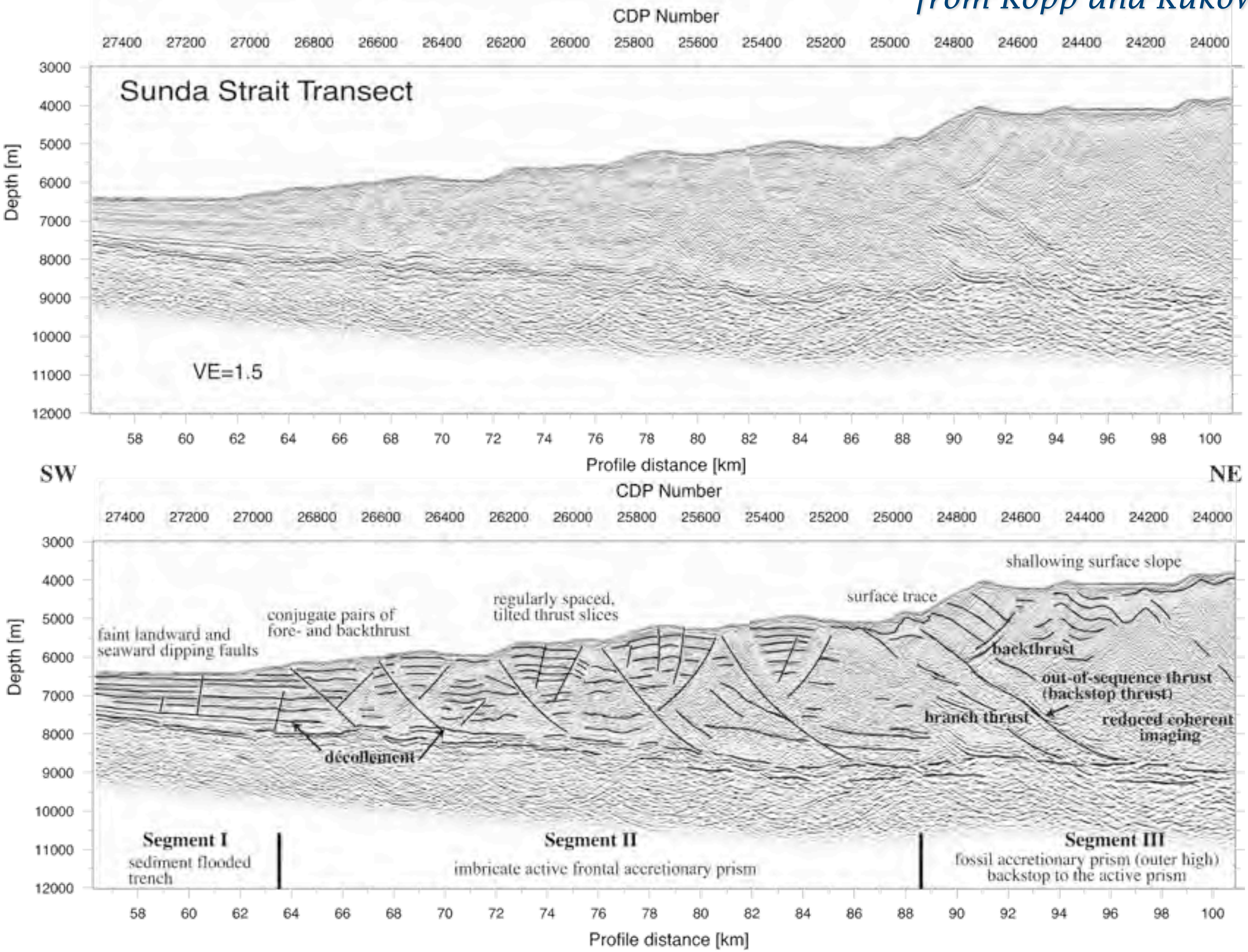
Barbados accretionary prism

from Kopp

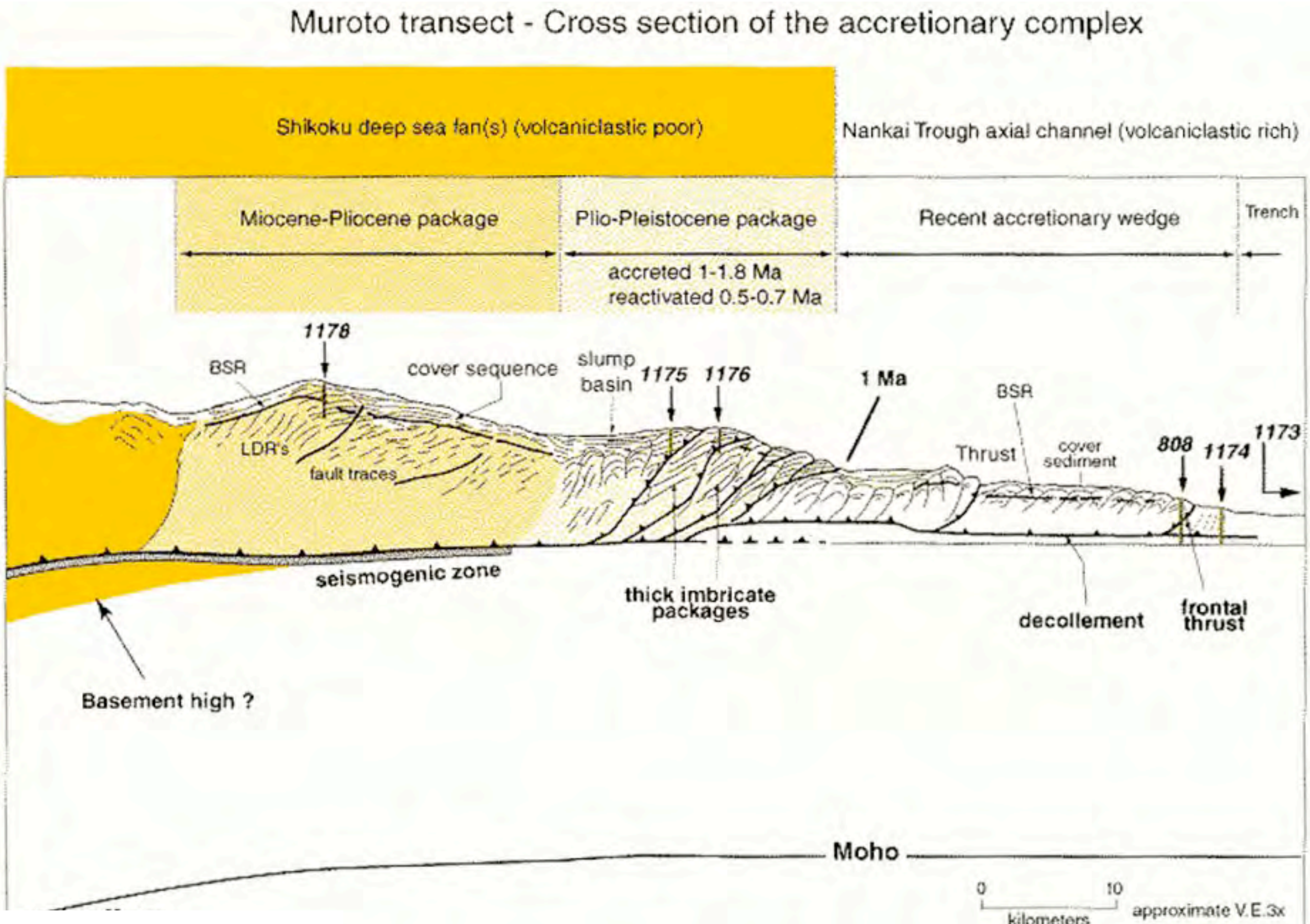

CDP Number
27250
27000
26750
26500
26250
26000
DEPTH [km]
5
6
7
8
9

Sunda wedge

from Kopp and Kukowski

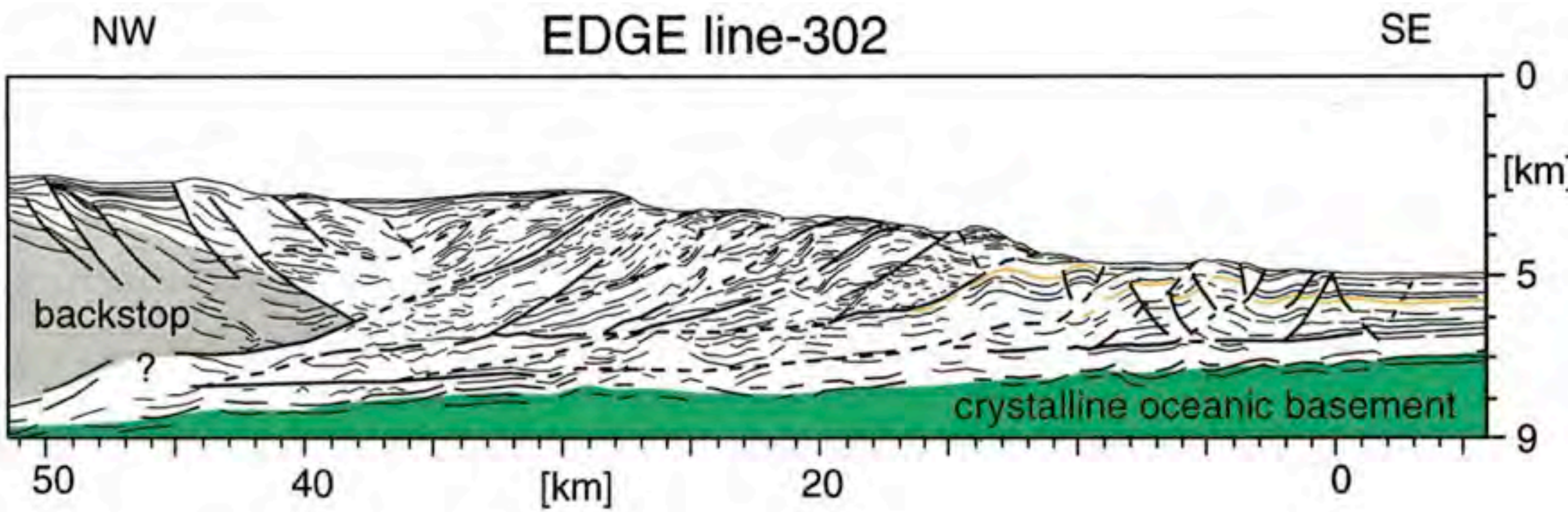


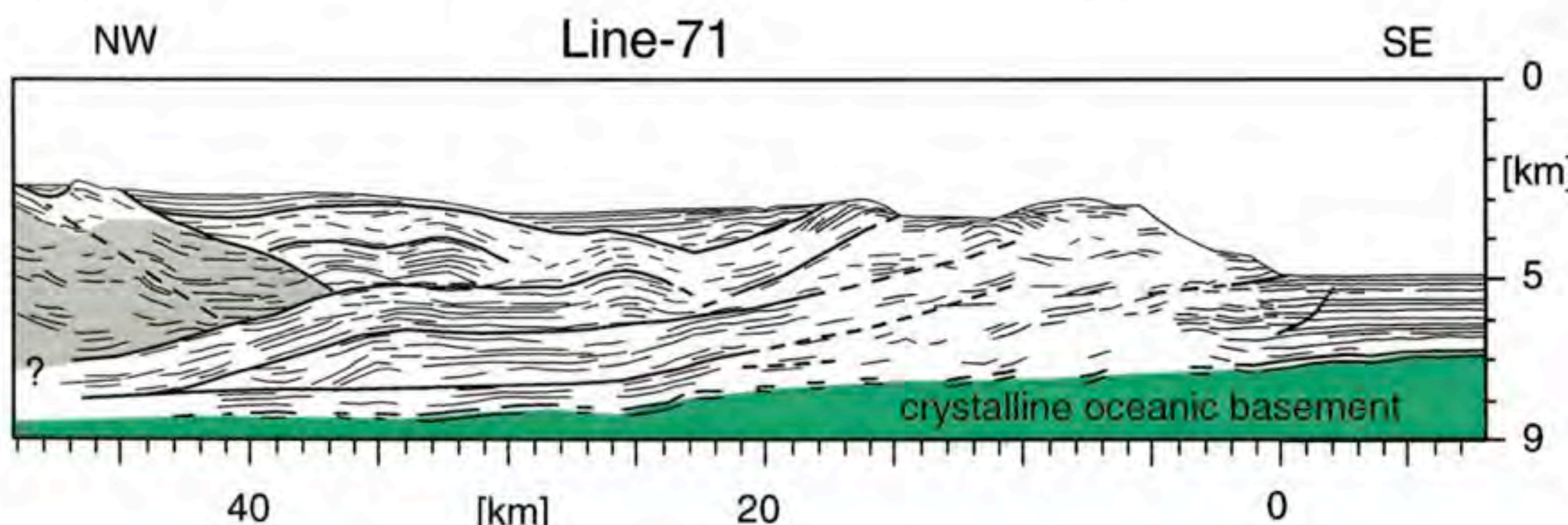
Nankai wedge (Japan)



P. Henry & JOIDES Team

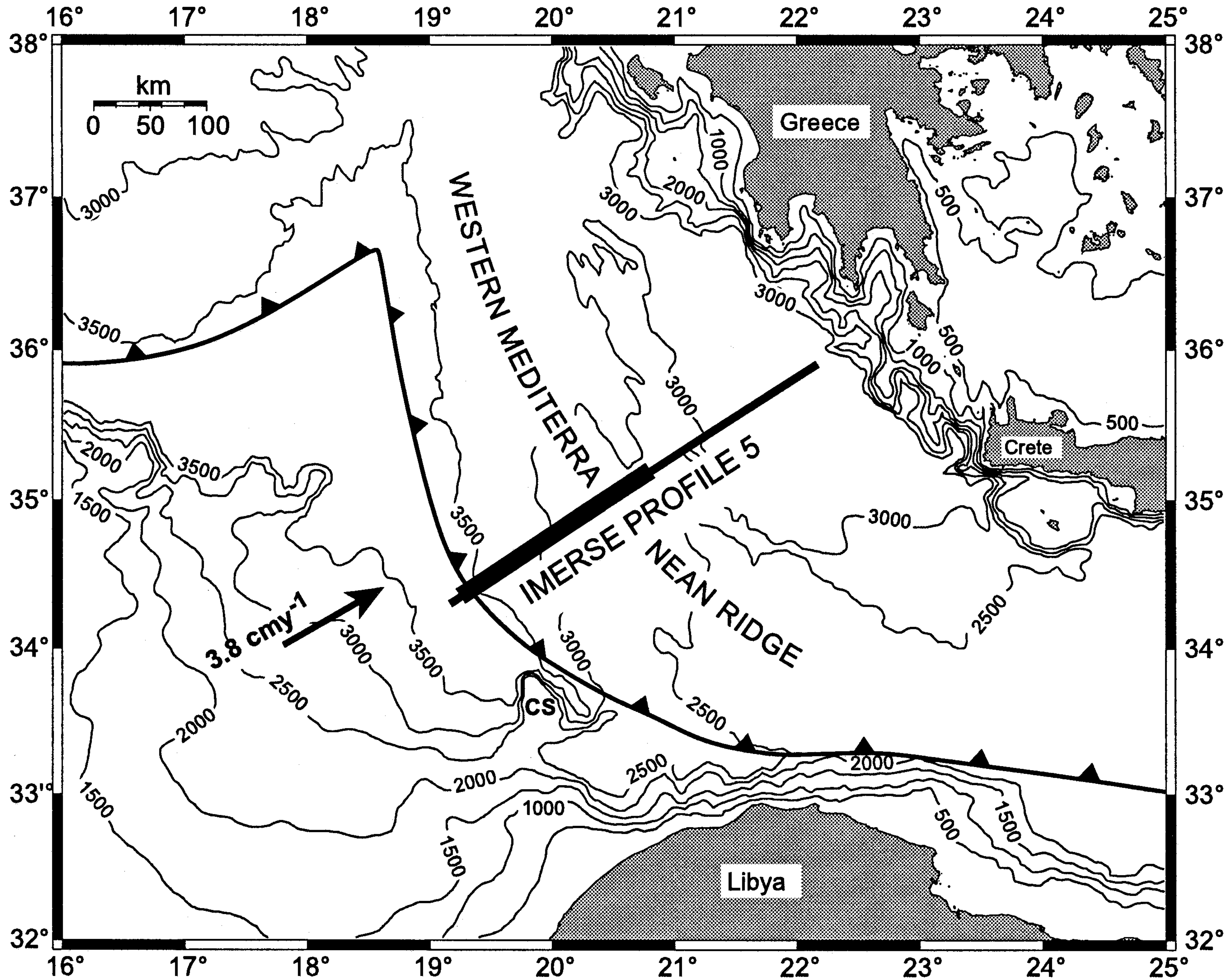
Cascadia wedge





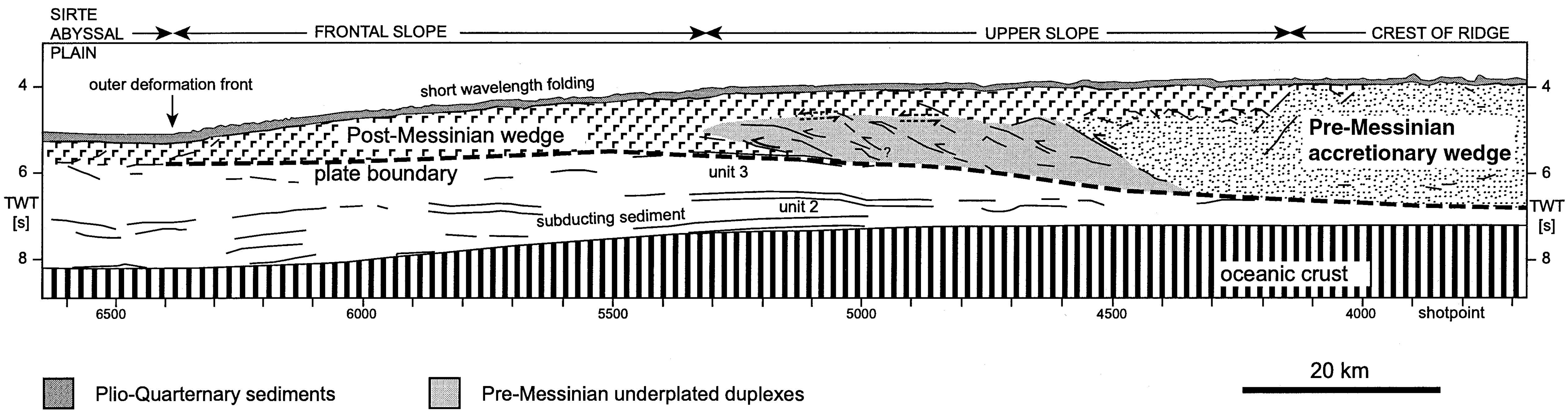
Gutscher et al., 1996

Ionian Sea wedge



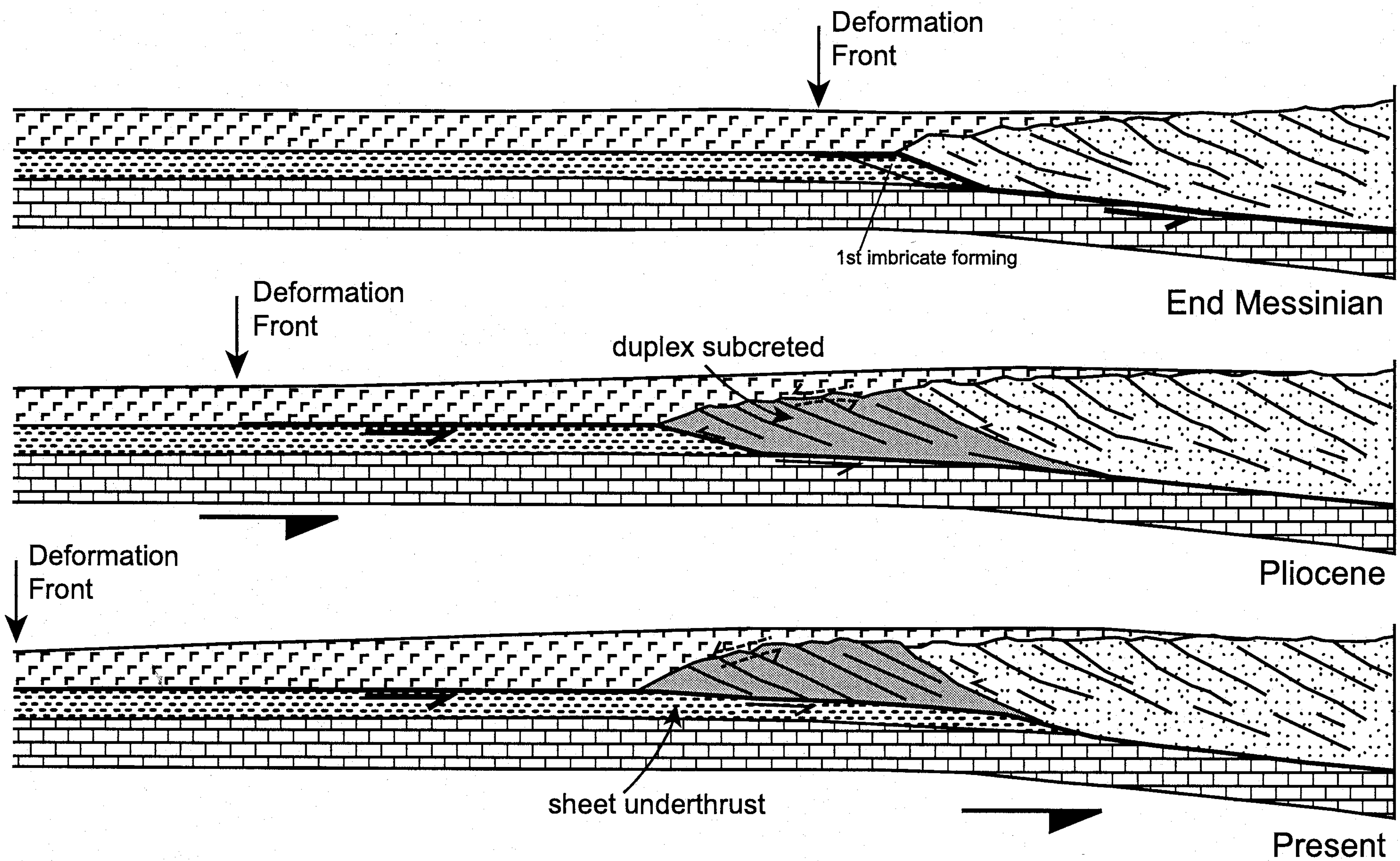
Kukowski et al., 2002

Ionian Sea wedge



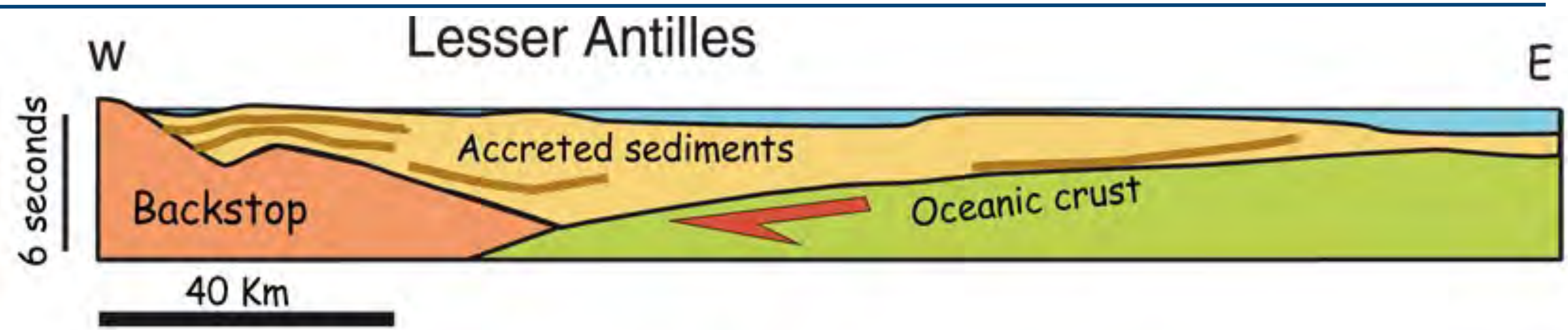
Kukowski et al., 2002

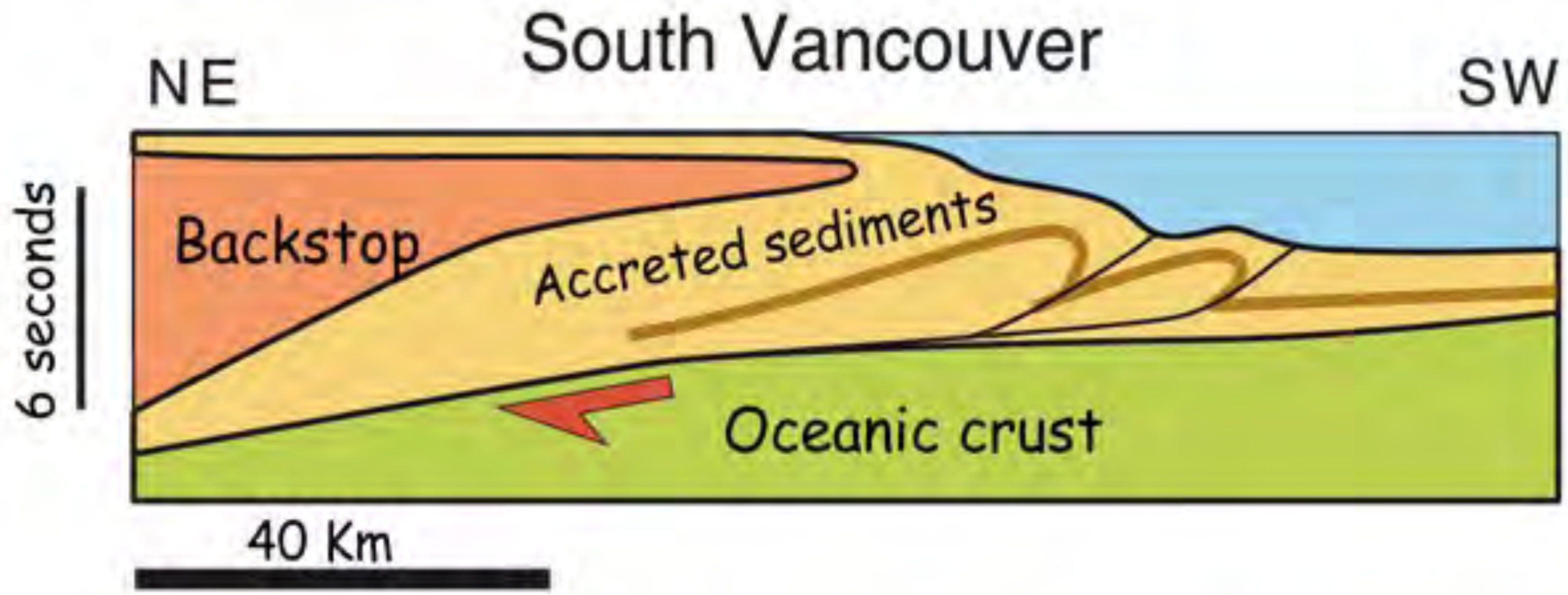
Ionian Sea wedge

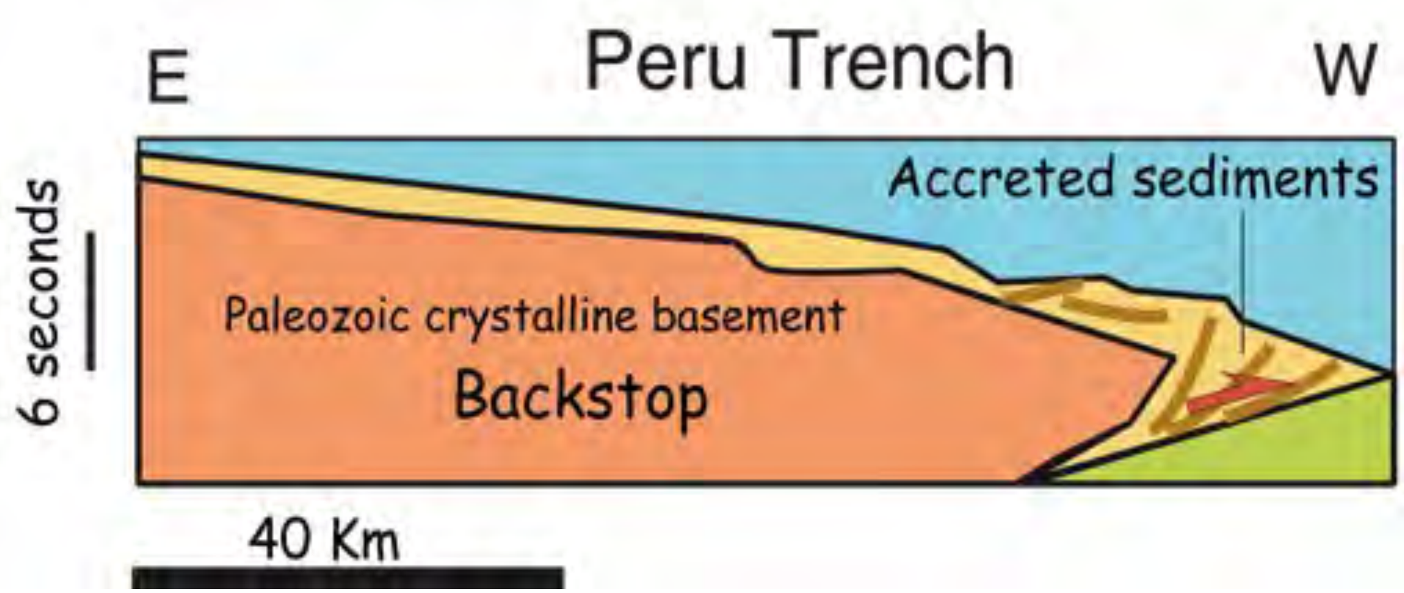


Kukowski et al., 2002

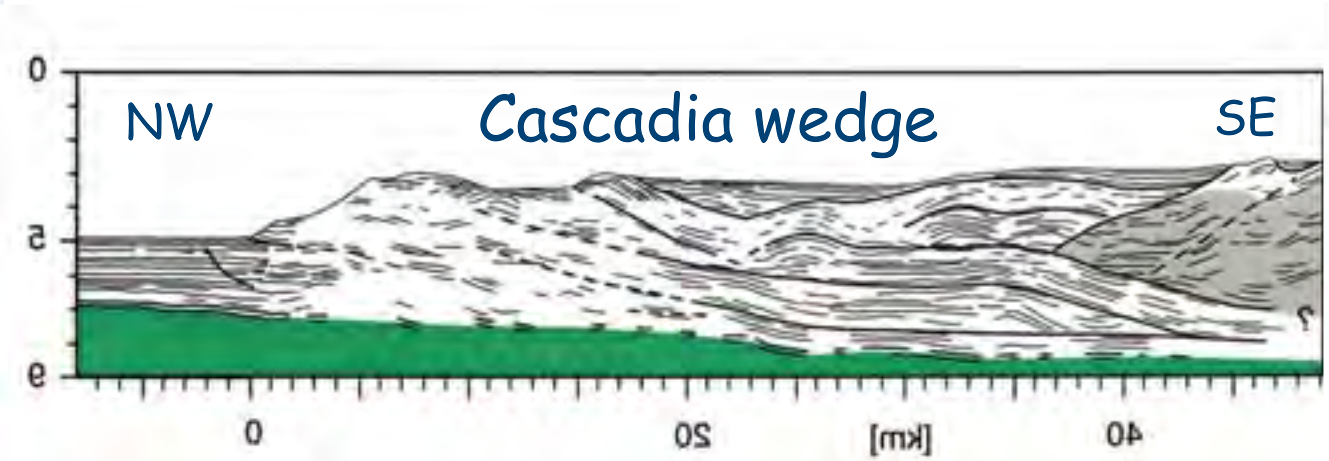
Types of accretionary wedge



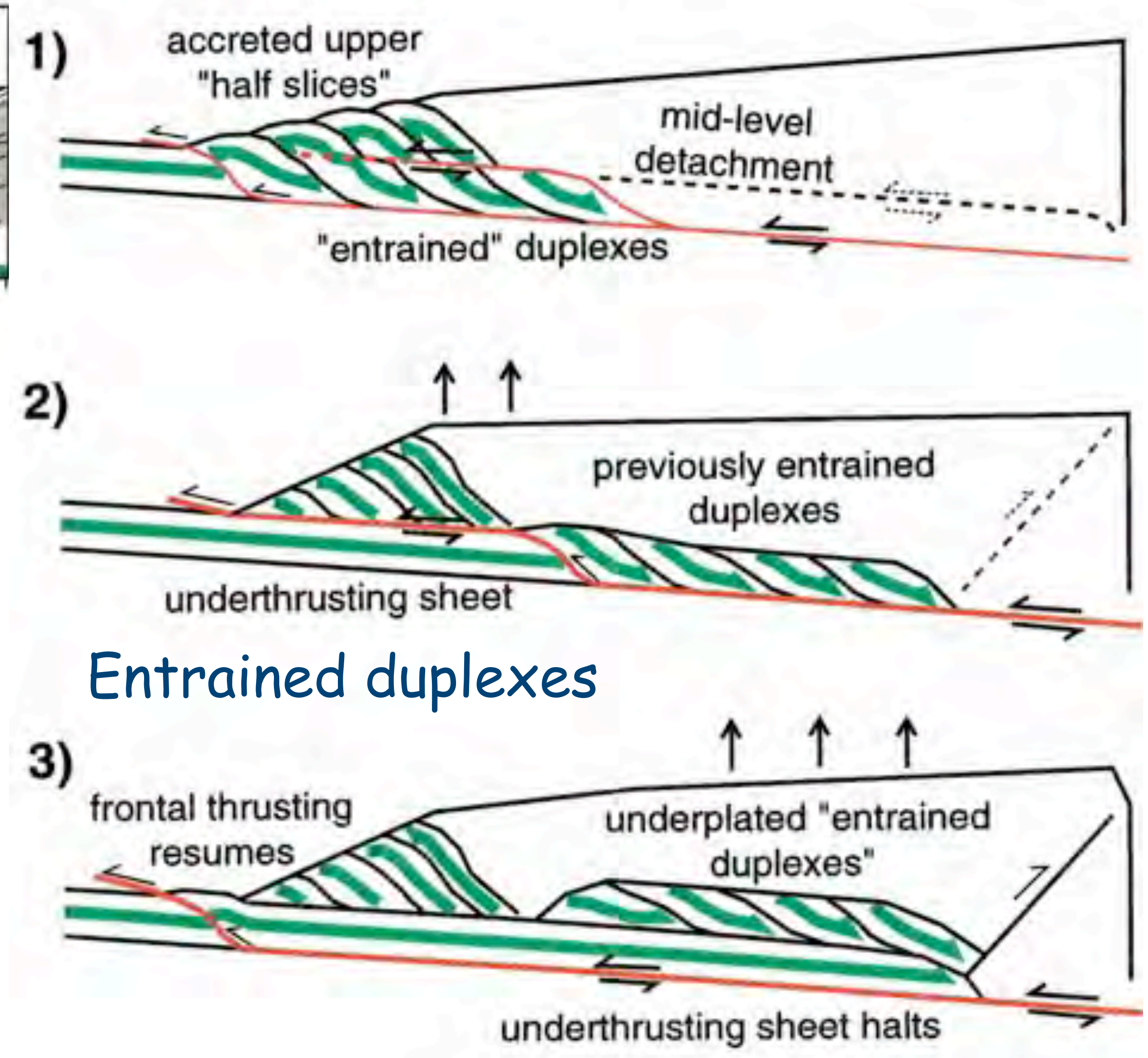




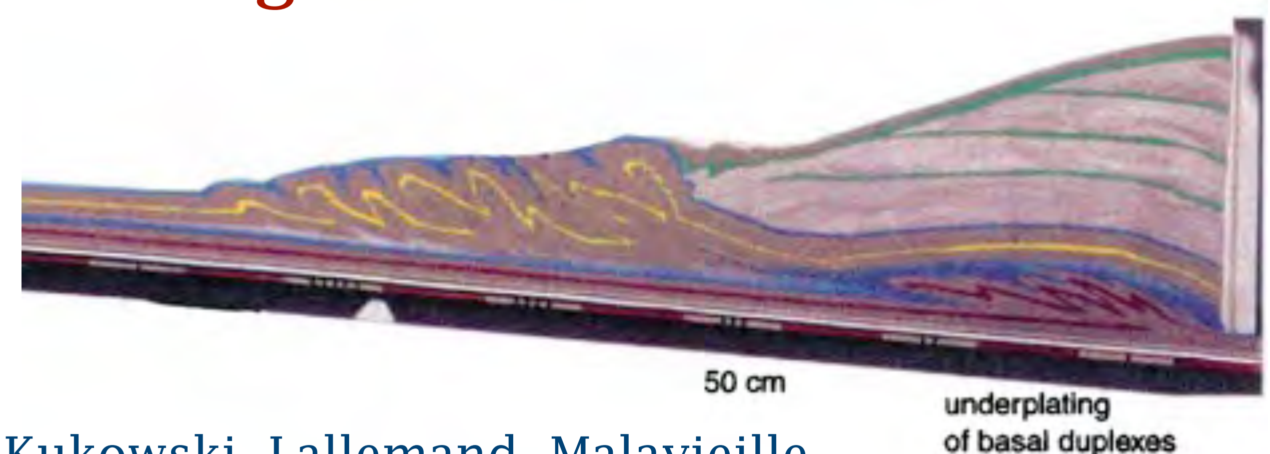
Mechanisms of accretion



Gutscher, M.A., Kukowski, N., Malavieille, J., and Lallemand, S., 1998, JGR



Changes in detachment levels



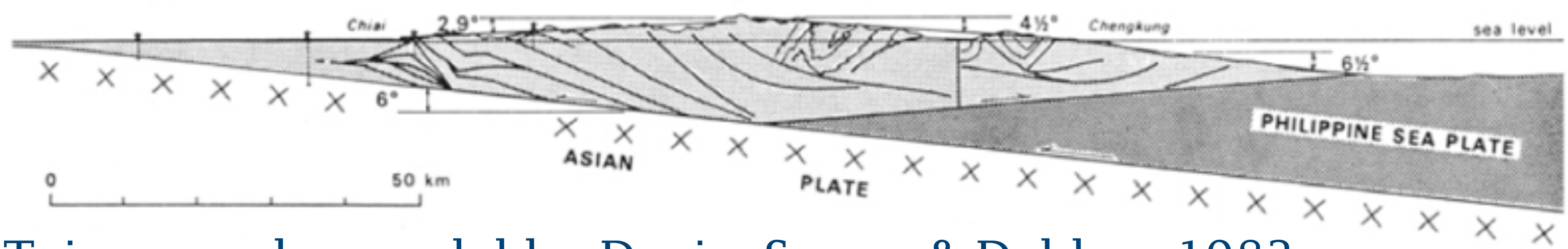
Kukowski, Lallemand, Malavieille, Gutscher & Reston, 2002, Marine Geology

Underplating + Frontal accretion

- Strain partitioning
- Two different growth processes acting simultaneously

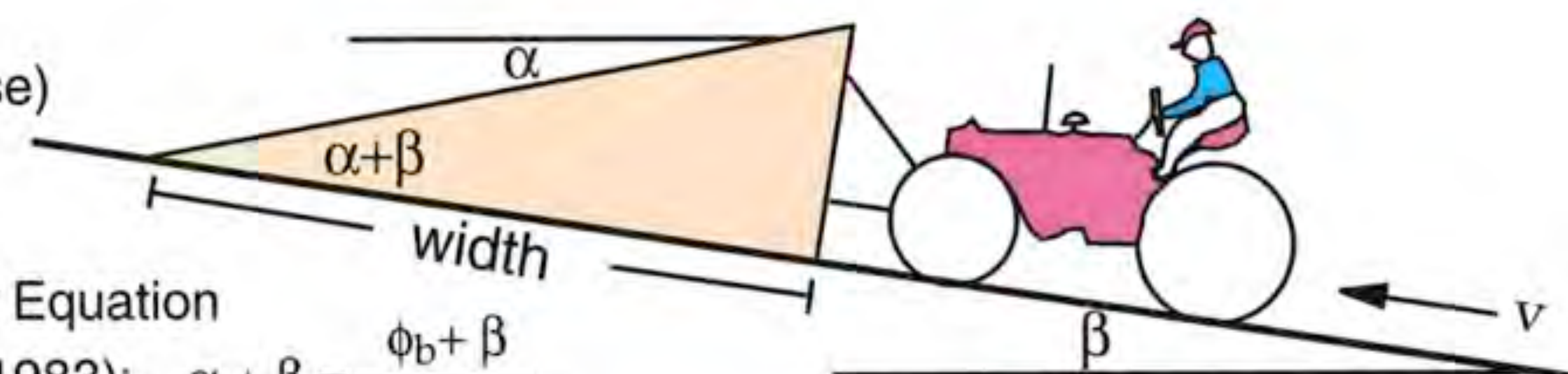
Mechanisms of accretion

In the eighties, **mechanical modeling** of mountain building bring geologists to consider mountain belts as **crustal scale accretionary wedges.**



Taiwan wedge model by Davis, Suppe & Dahlen, 1983

-> Coulomb wedge theory (The wedge is considered to deform homogeneously).

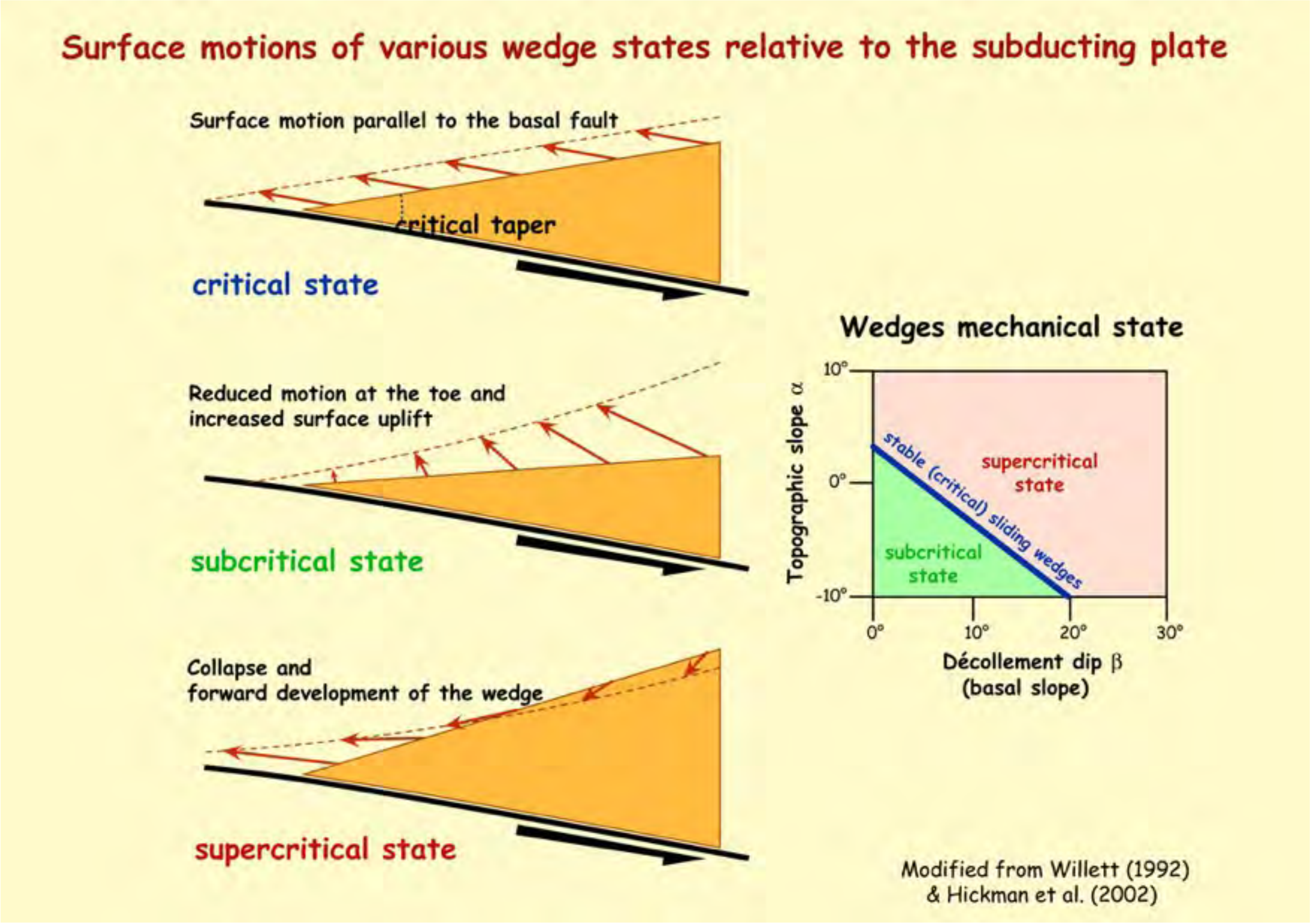


Critical Taper Equation (Davis et al., 1983): $\alpha + \beta = \frac{\phi_b + \beta}{1 + K}$

where $\mu_b = \tan \phi_b$

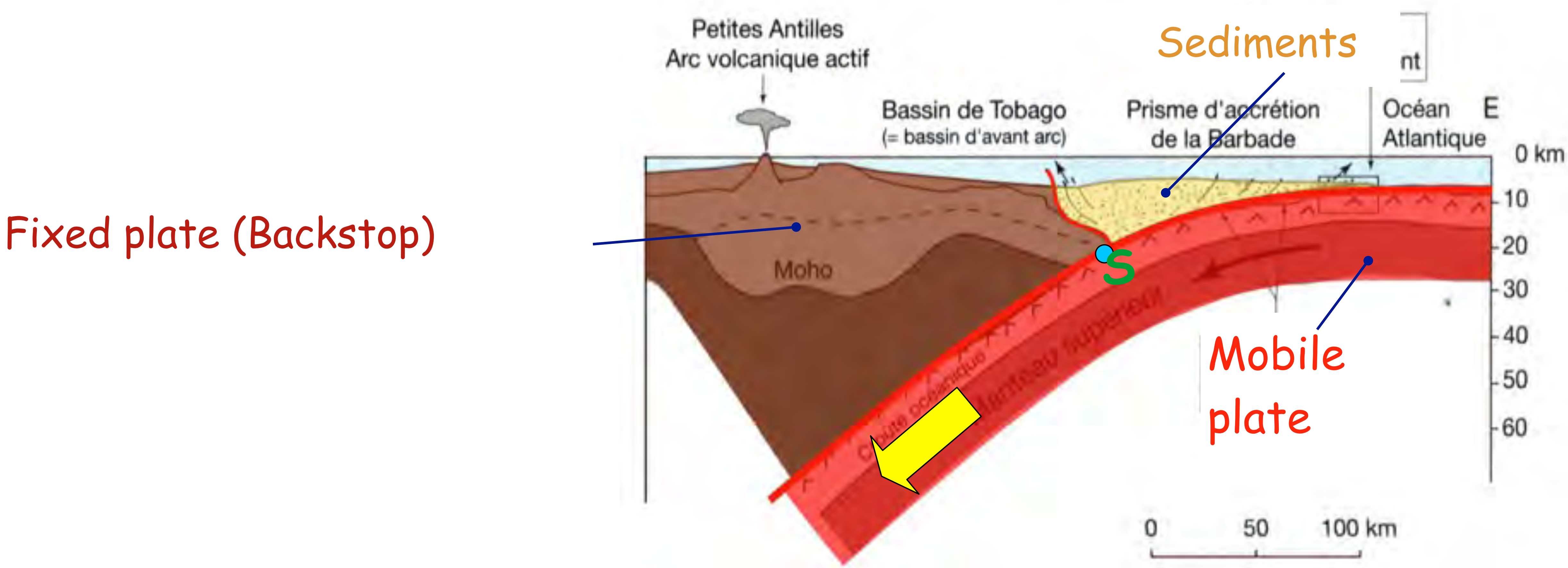
*** Different tectonic regimes depending on wedge stability : critical, subcritical, supercritical…**

Critical taper



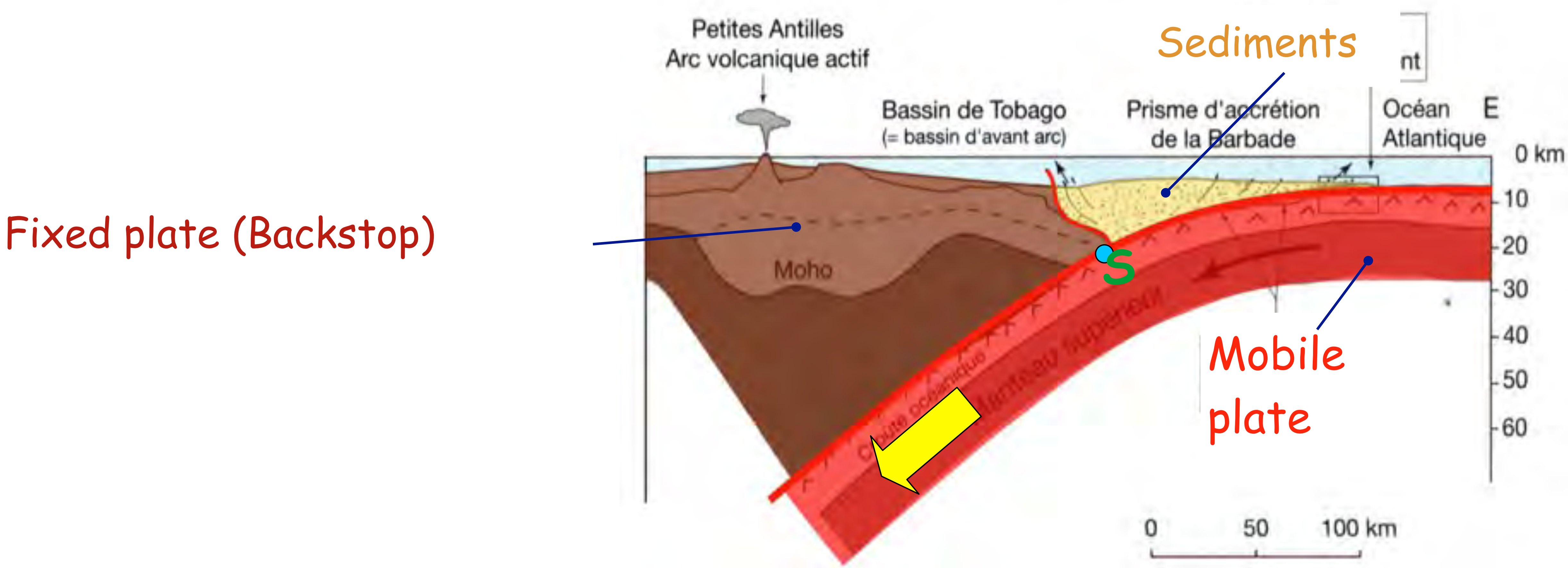
do not give any information on how the interior of the wedge deforms

Modeling accretionary wedge

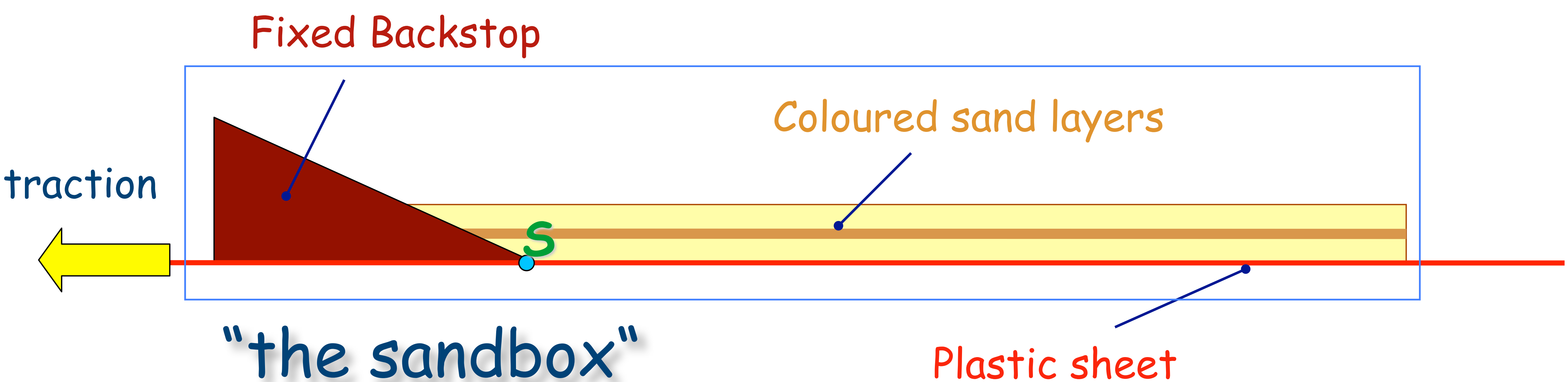


Malavieille, com. pers.

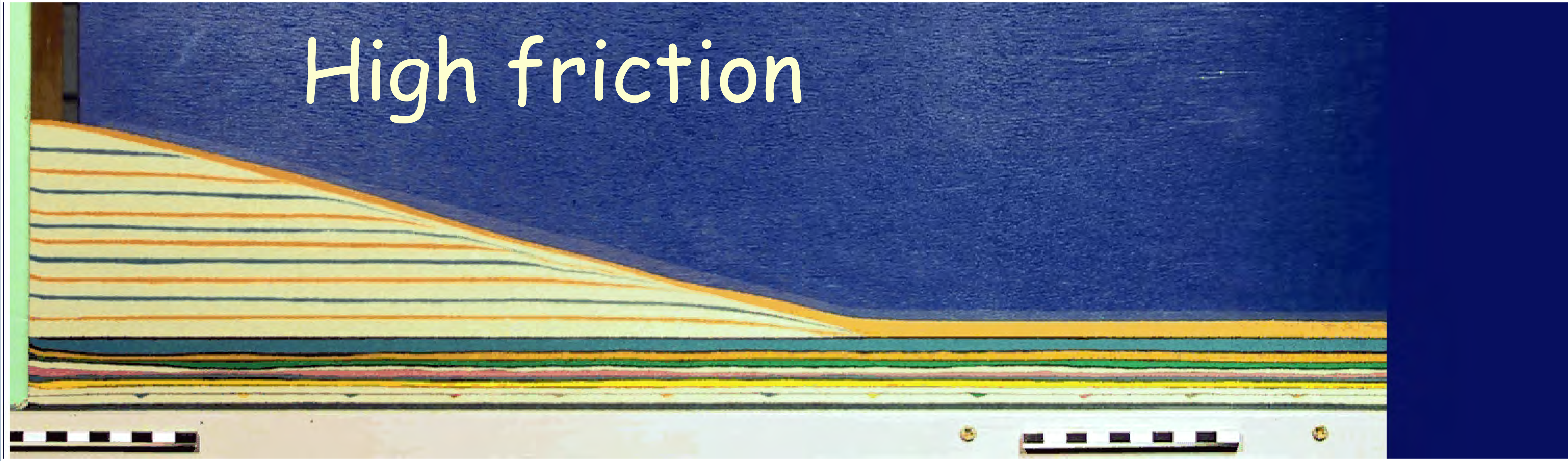
Modeling accretionary wedge

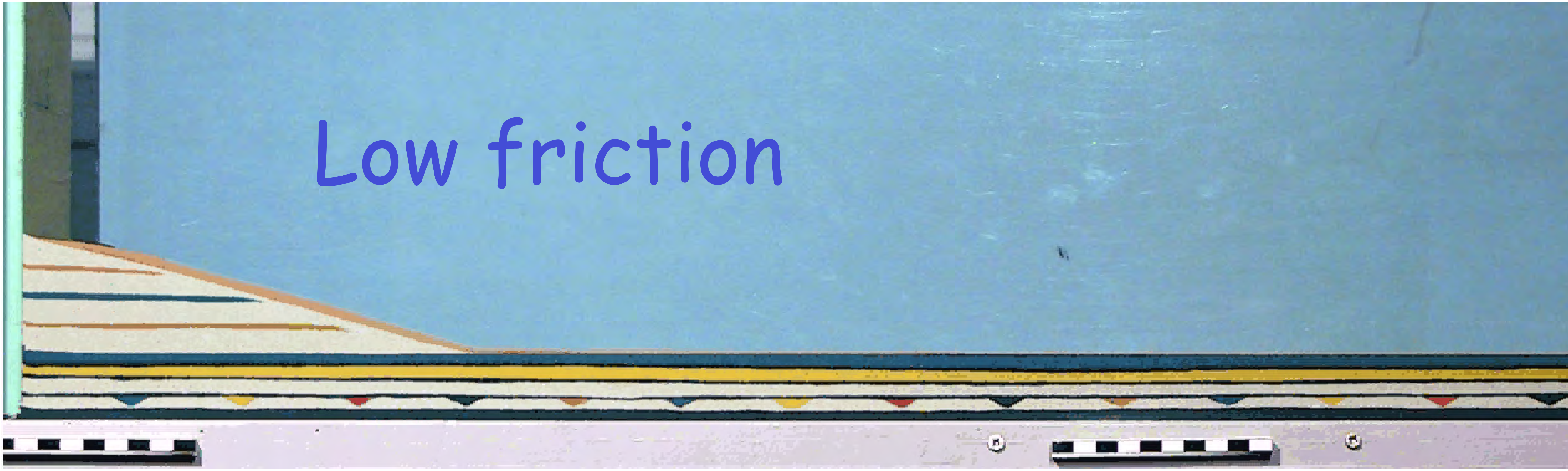


Malavieille, com. pers.



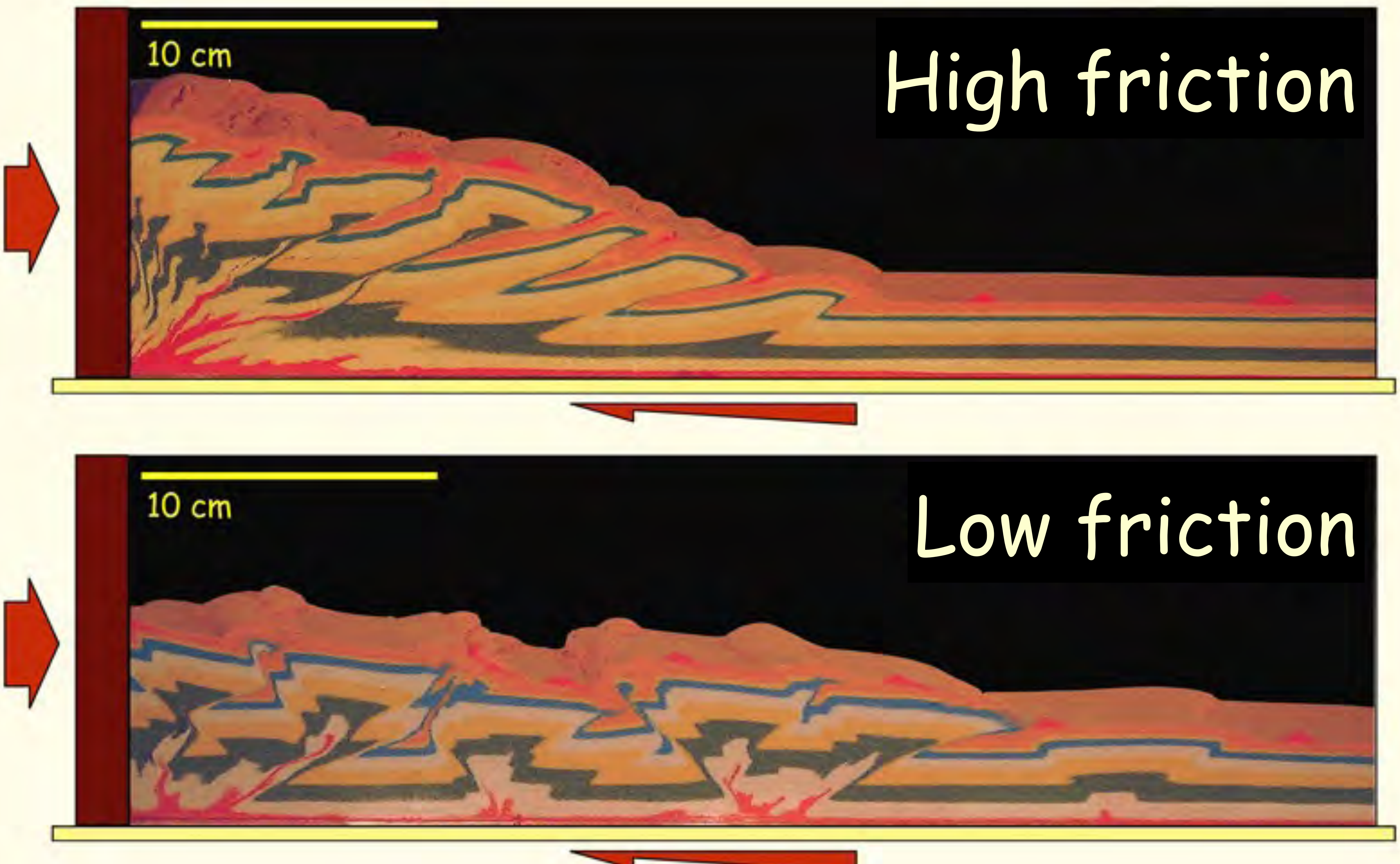
Modeling accretionary wedge





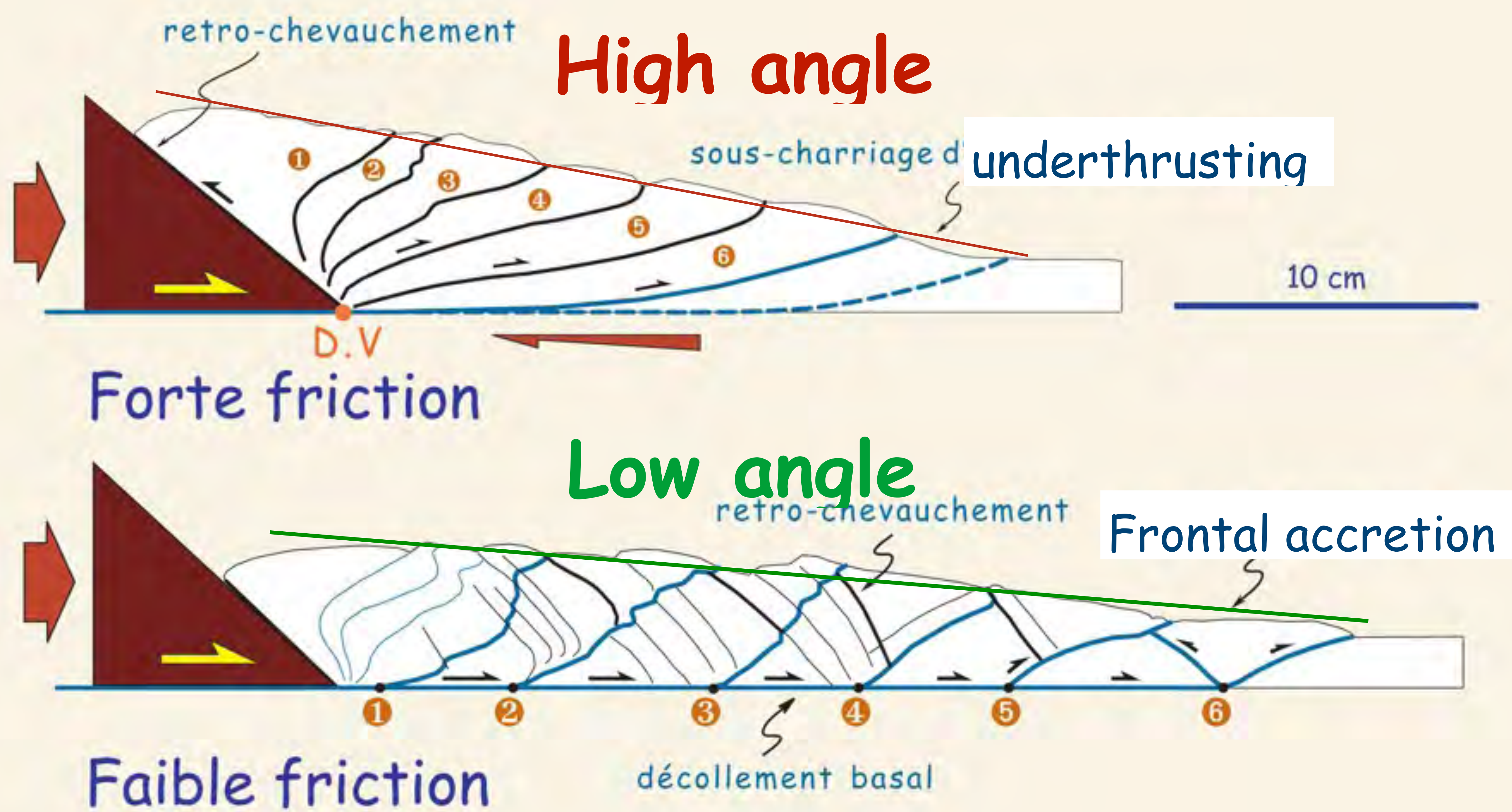
Malavieille, com. pers.

Modeling accretionary wedge



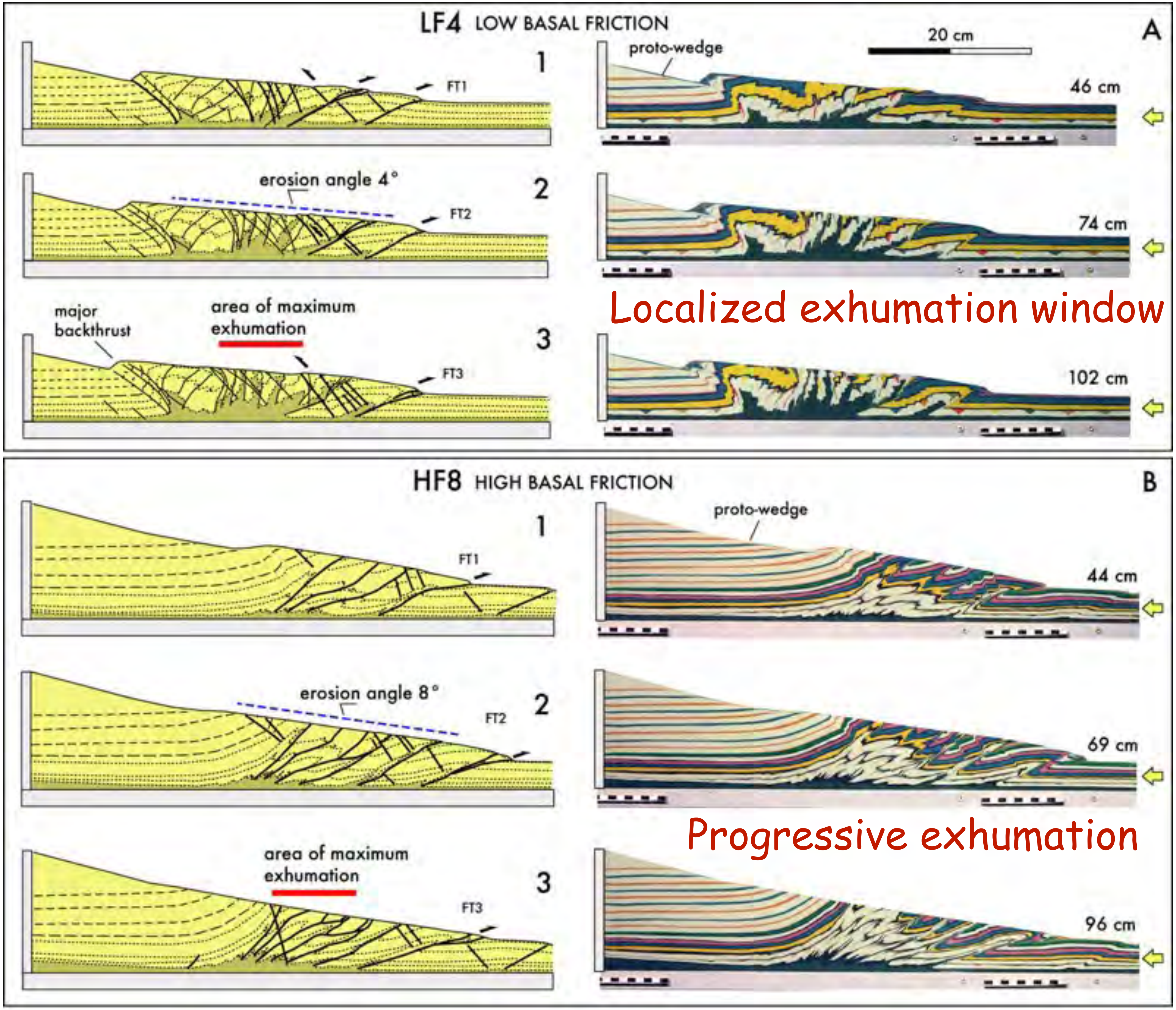
Malavieille, com. pers.

Modeling accretionary wedge



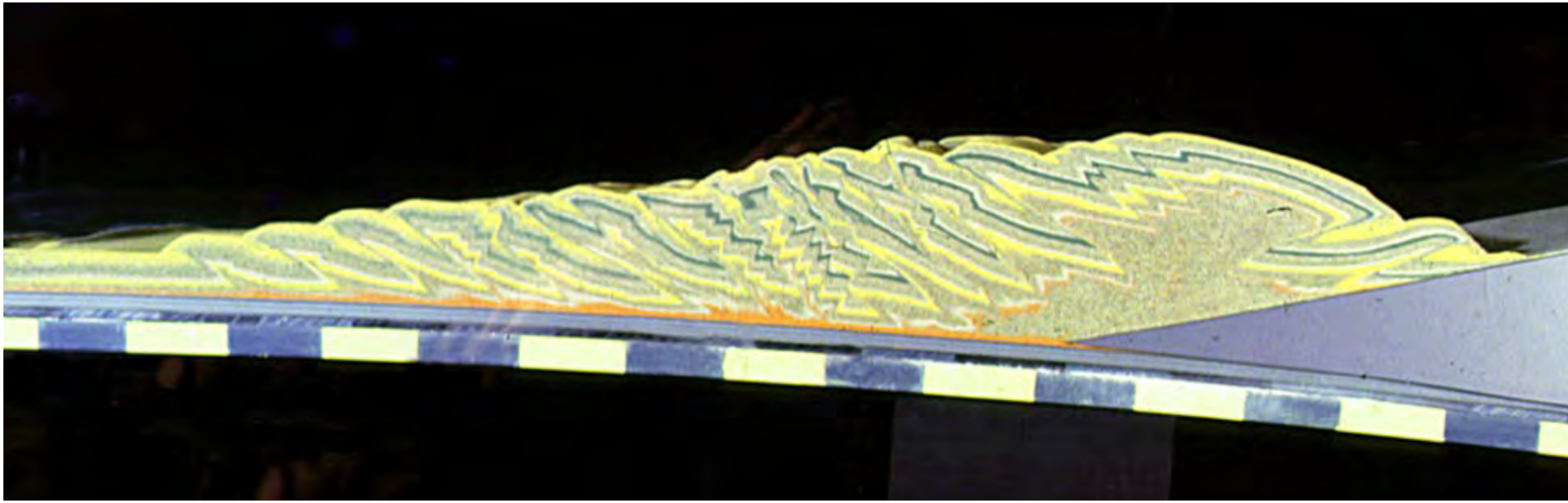
Biagi & Malavieille, 1987

Modeling accretionary wedge



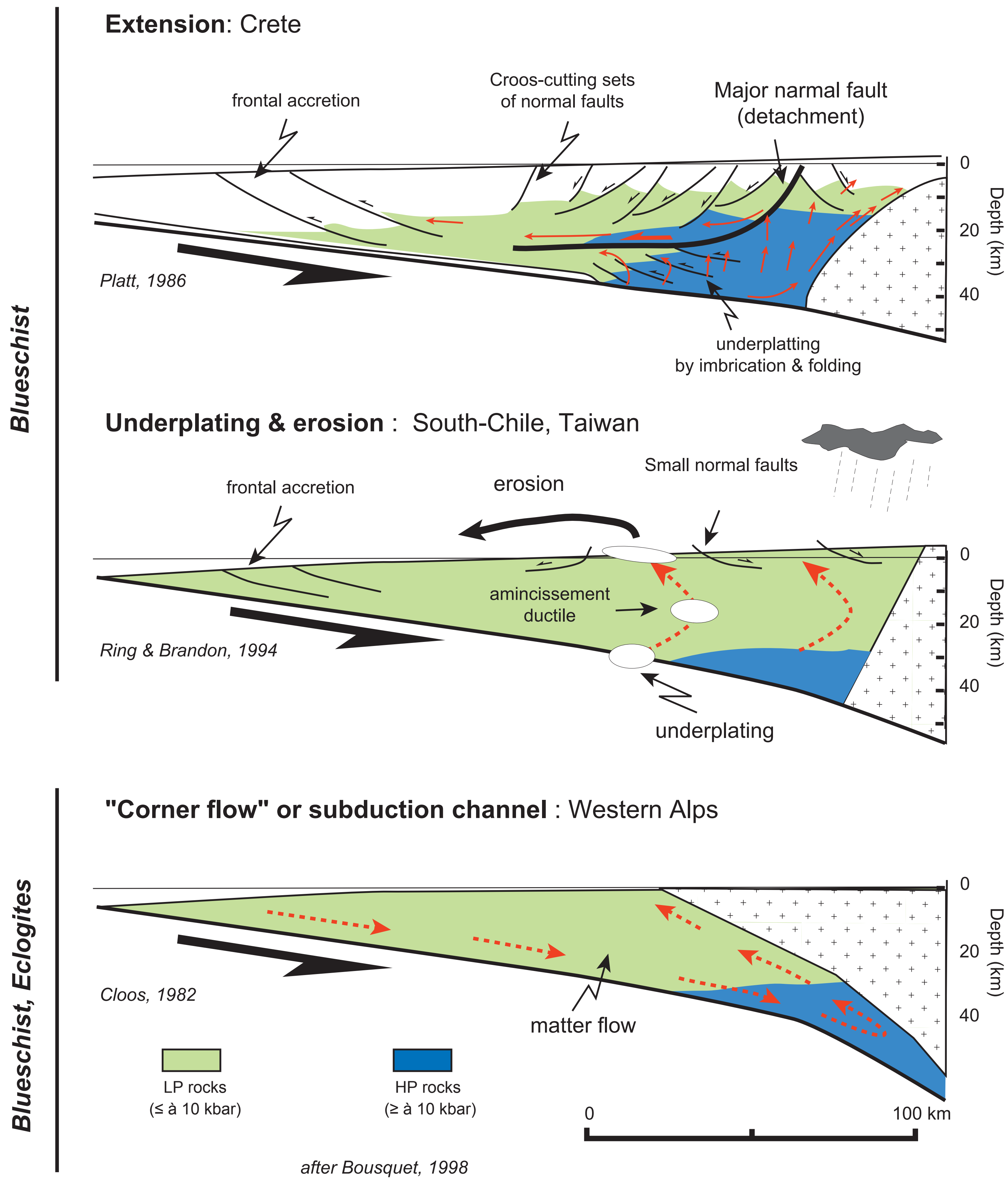
R. Bousquet 2009-2010

Impact of backstop geometry



Malavieille & Biaggi., 1987

Types of wedge & exhumation of HP rocks



Tectonic plates around Taiwan

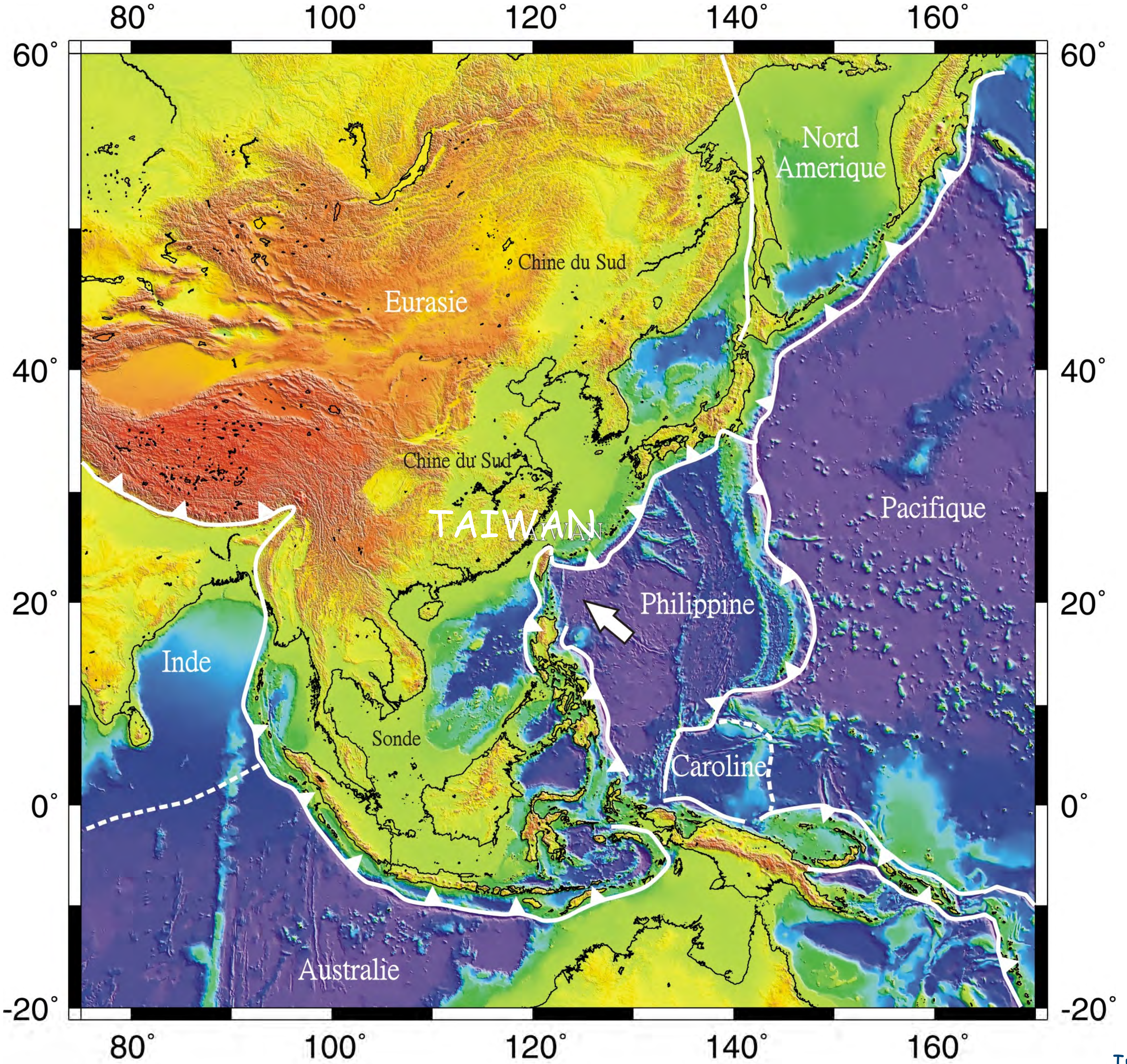
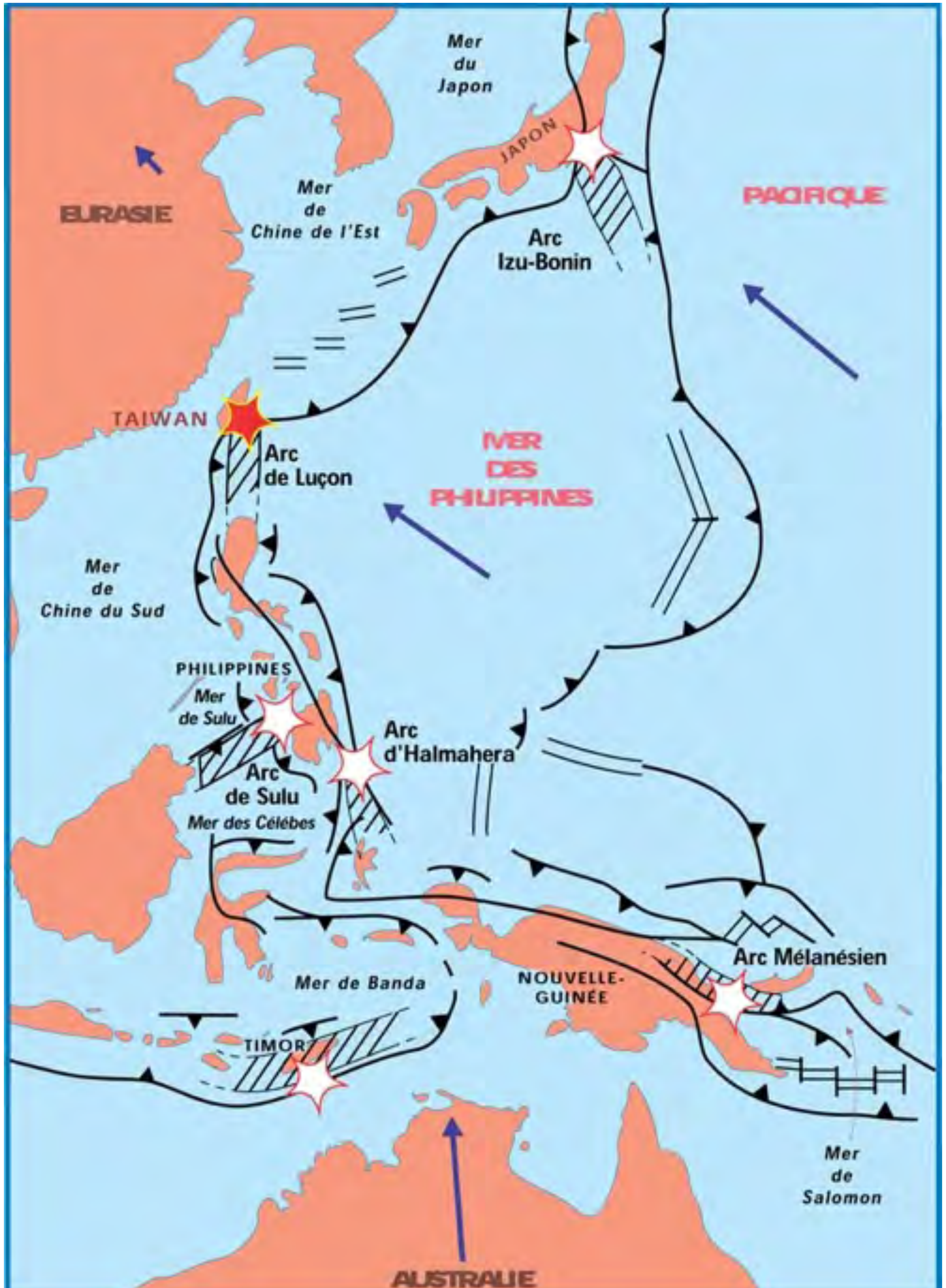


Image K-J Chang



Geodynamic setting

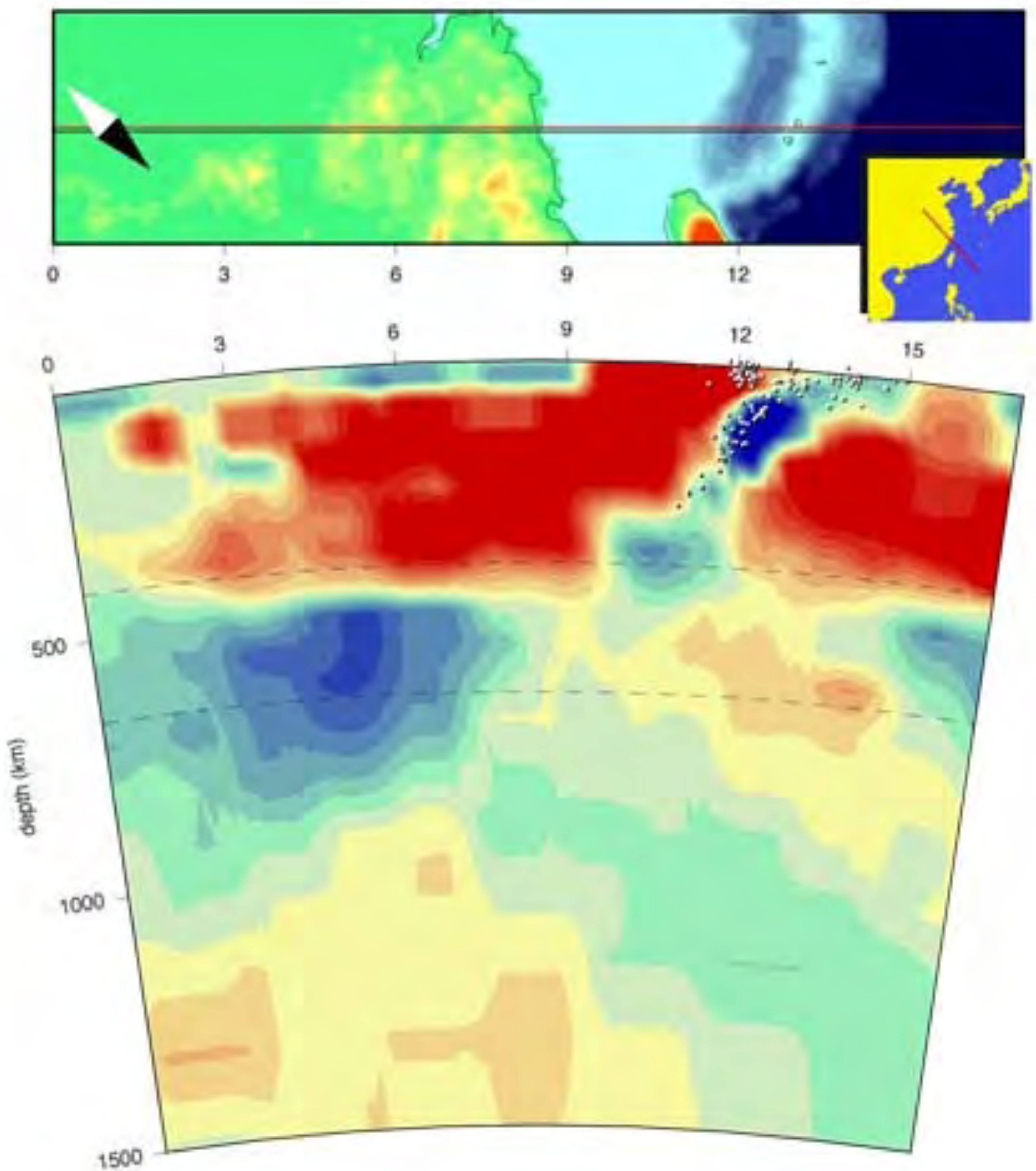
Taiwan, The classical example of

Arc-continent collision !

Why not?
But, what does it mean?

Tomography below Taiwan

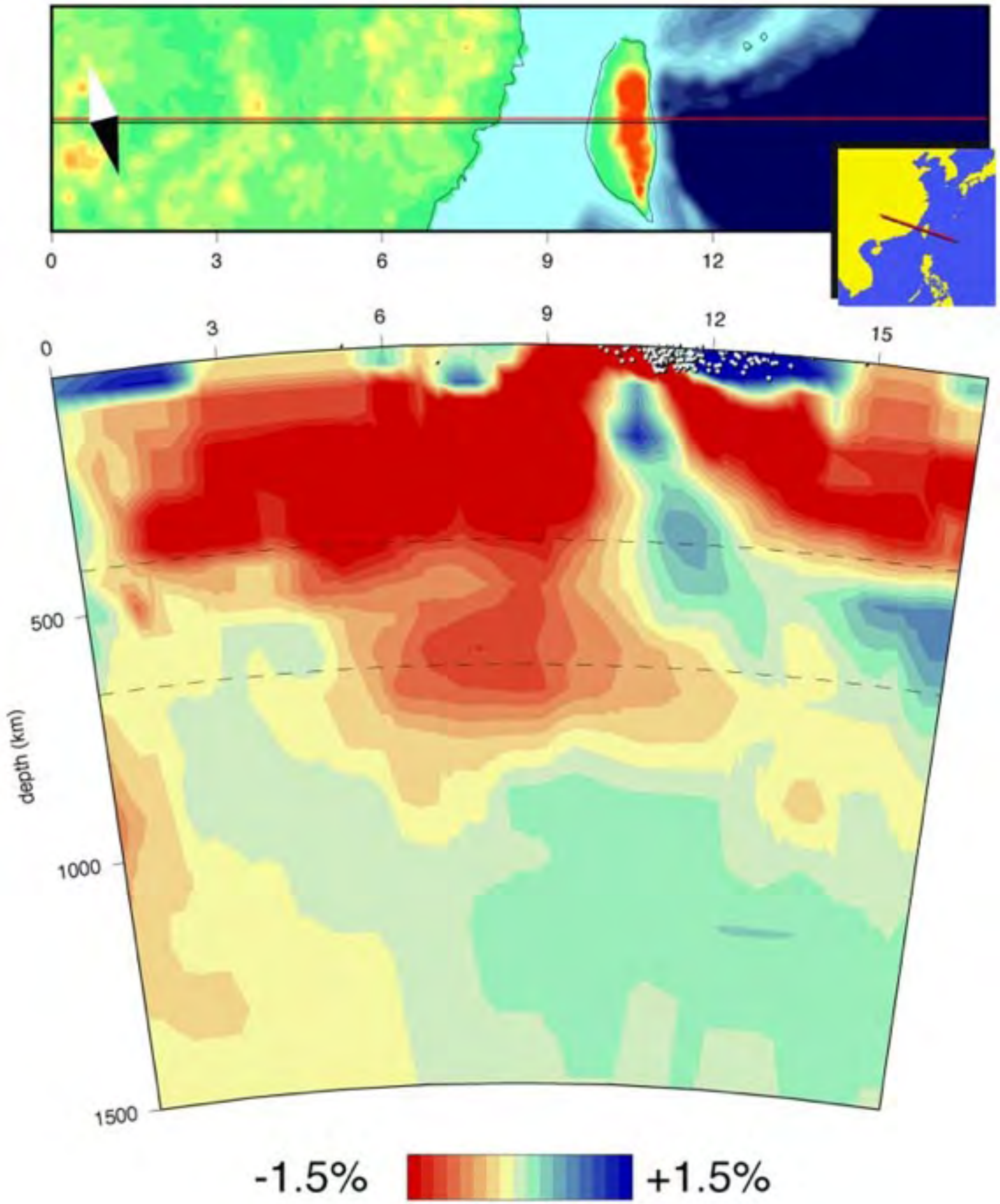
North profile



Lallemand et al., 2001

Tomography below Taiwan

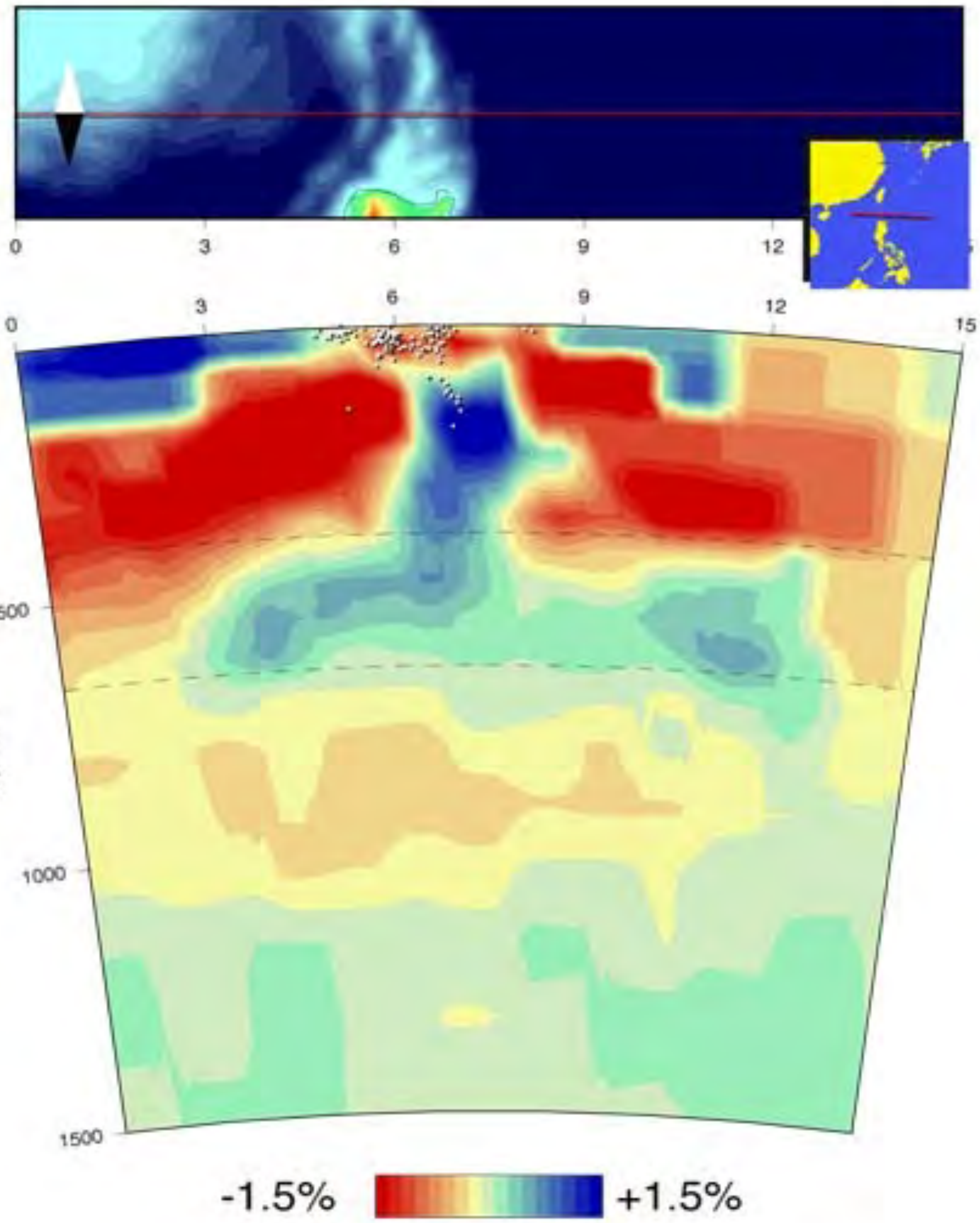
Profile in the Middle of the island



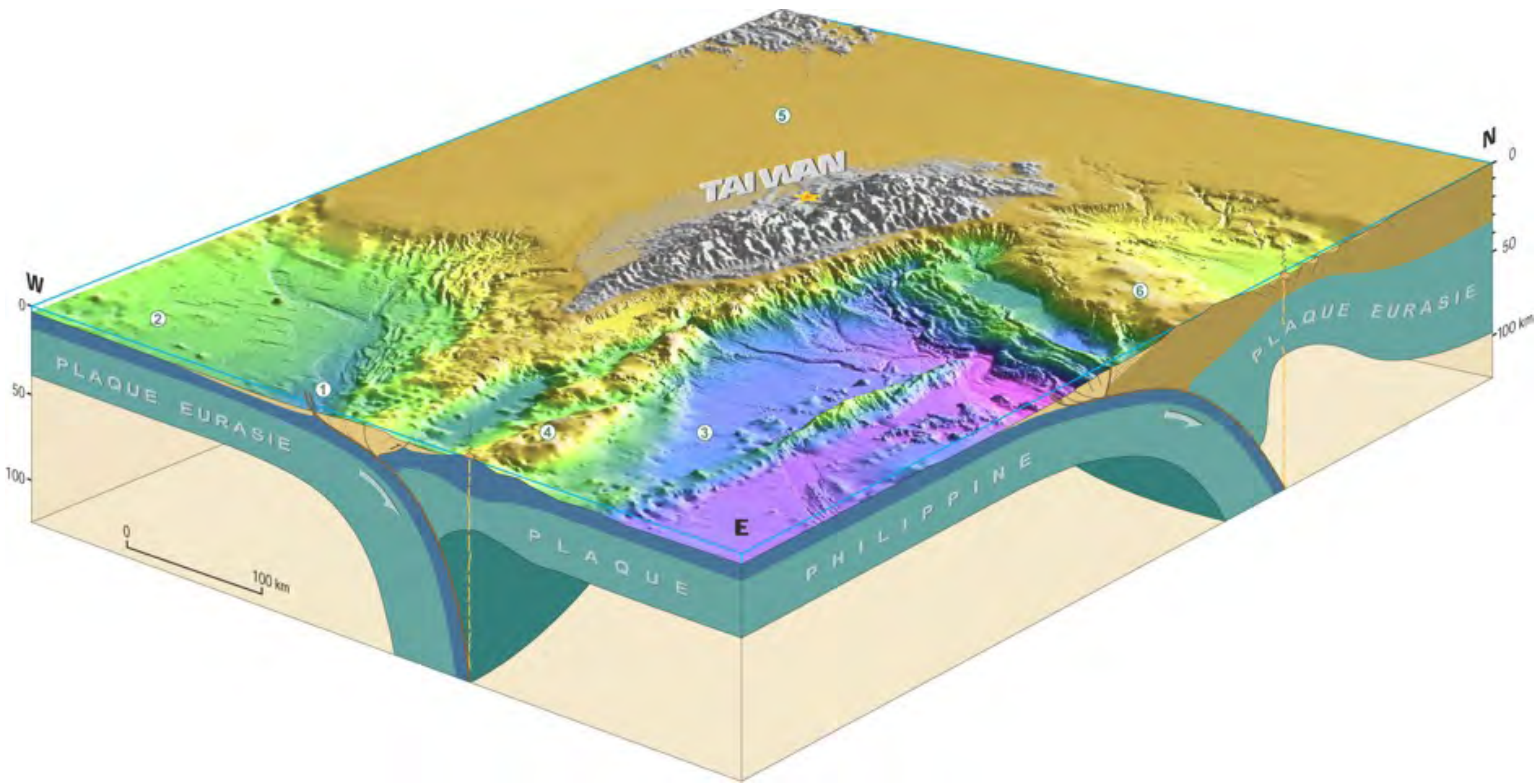
Lallemand et al., 200

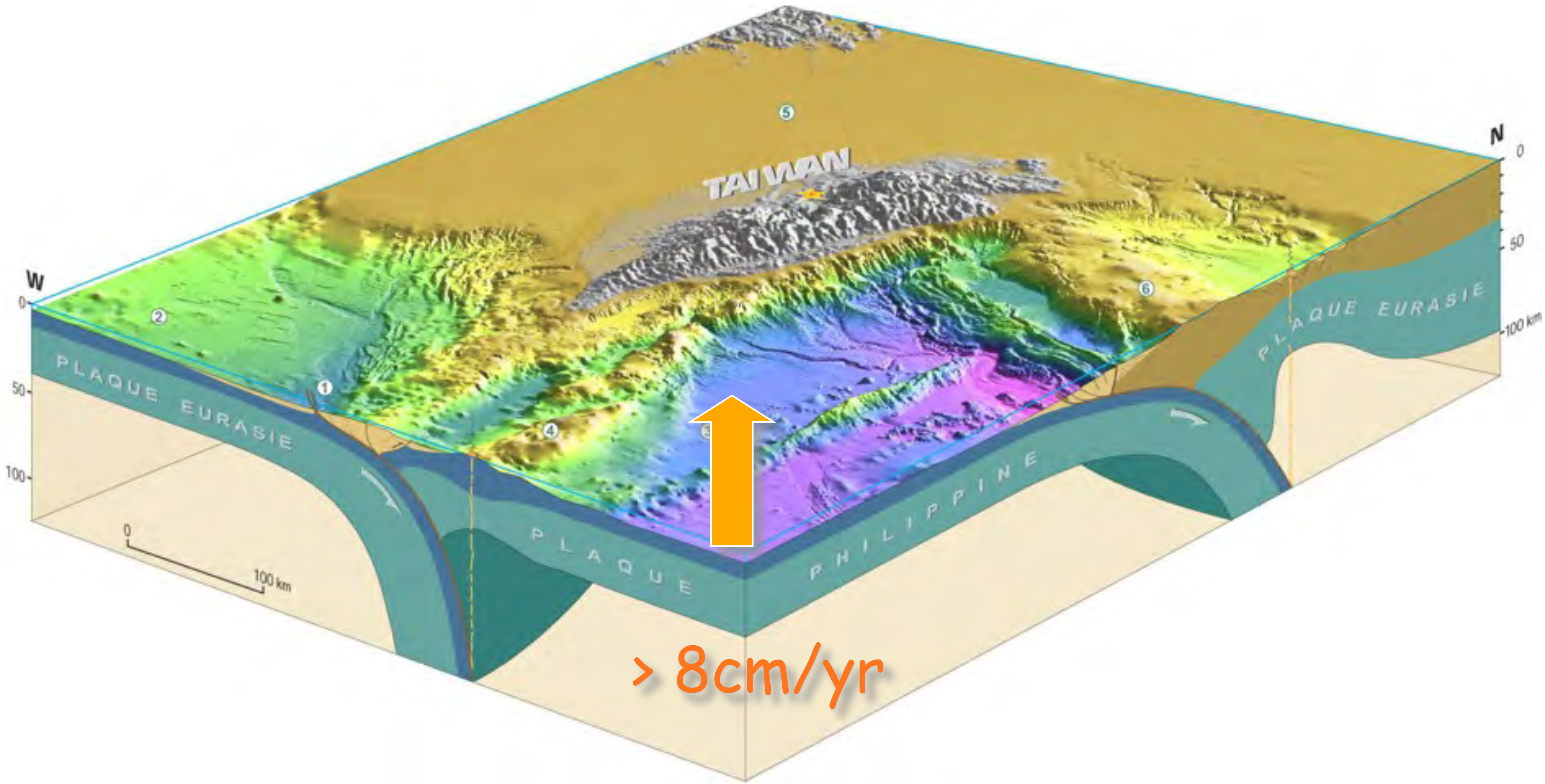
Tomography below Taiwan

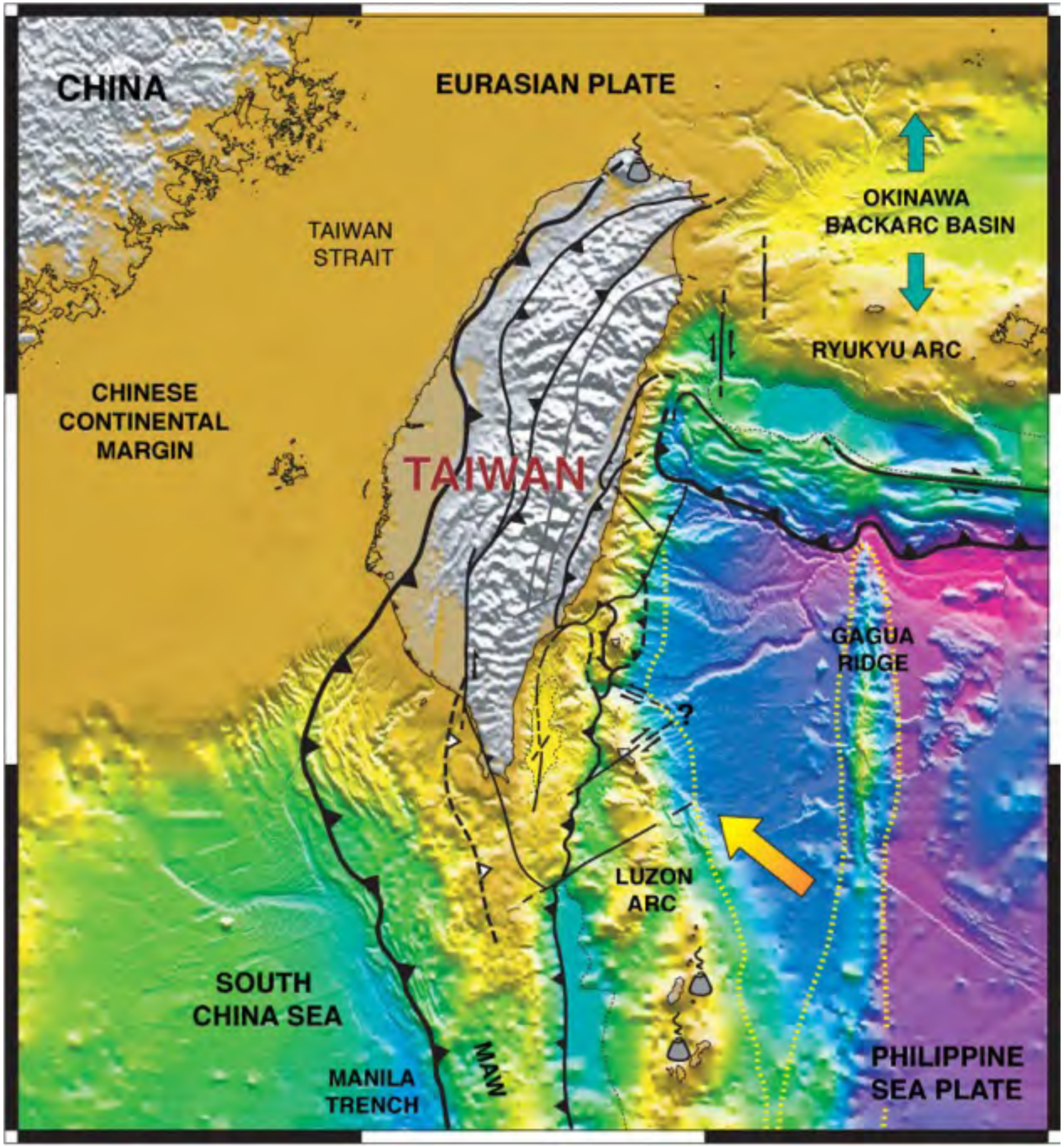
South profile



Lallemand et al., 2001

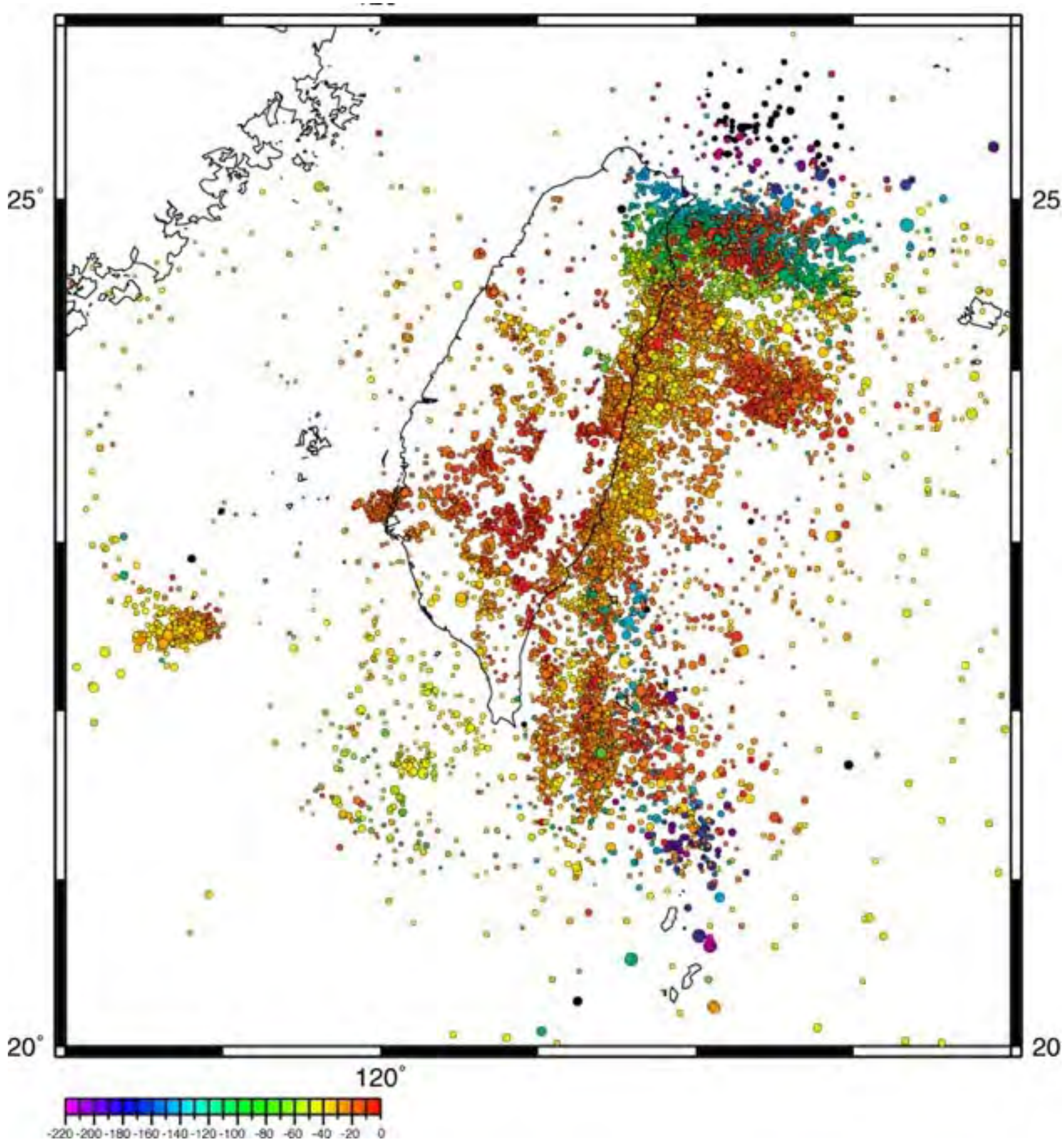

TAIWAN
W
N
E
0
50
100
0
50
100 km
PLAQUE EURASIE
PLAQUE EURASIE
PLAQUE PHILIPPINE
0
100 km
1
2
3
4
5
6


TAIWAN
W
N
0
50
100
100 km
PLAQUE EURASIE
PLAQUE PHILIPPINE
PLAQUE EURASIE
> 8cm/yr

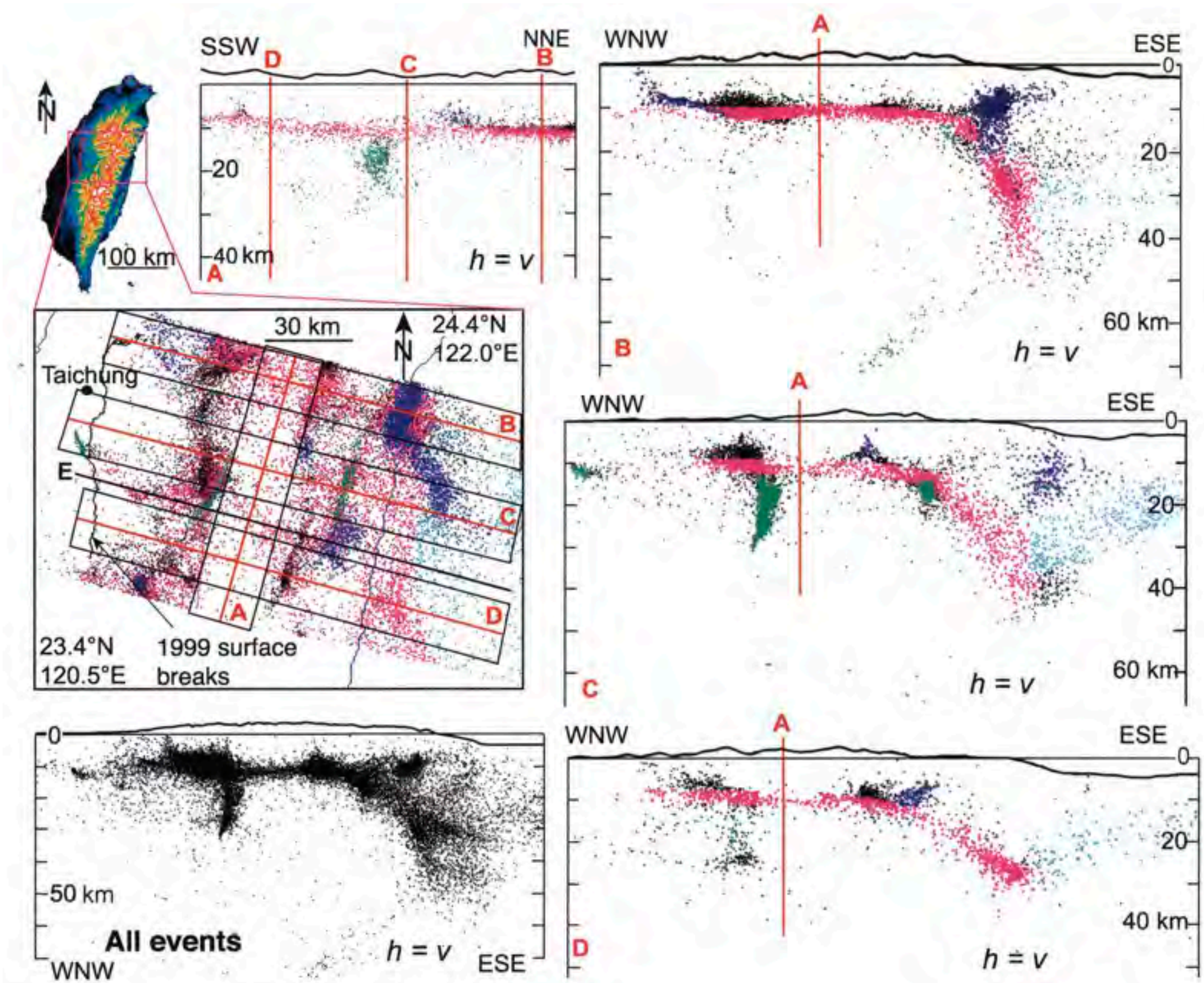

CHINA
EURASIAN PLATE
TAIWAN STRAIT
OKINAWA BACKARC BASIN
RYUKYU ARC
CHINESE CONTINENTAL MARGIN
TAIWAN
GAGUA RIDGE
LUZON ARC
SOUTH CHINA SEA
MANILA TRENCH
MAW
PHILIPPINE SEA PLATE

Seismicity around Taiwan

Seismicity around Taiwan

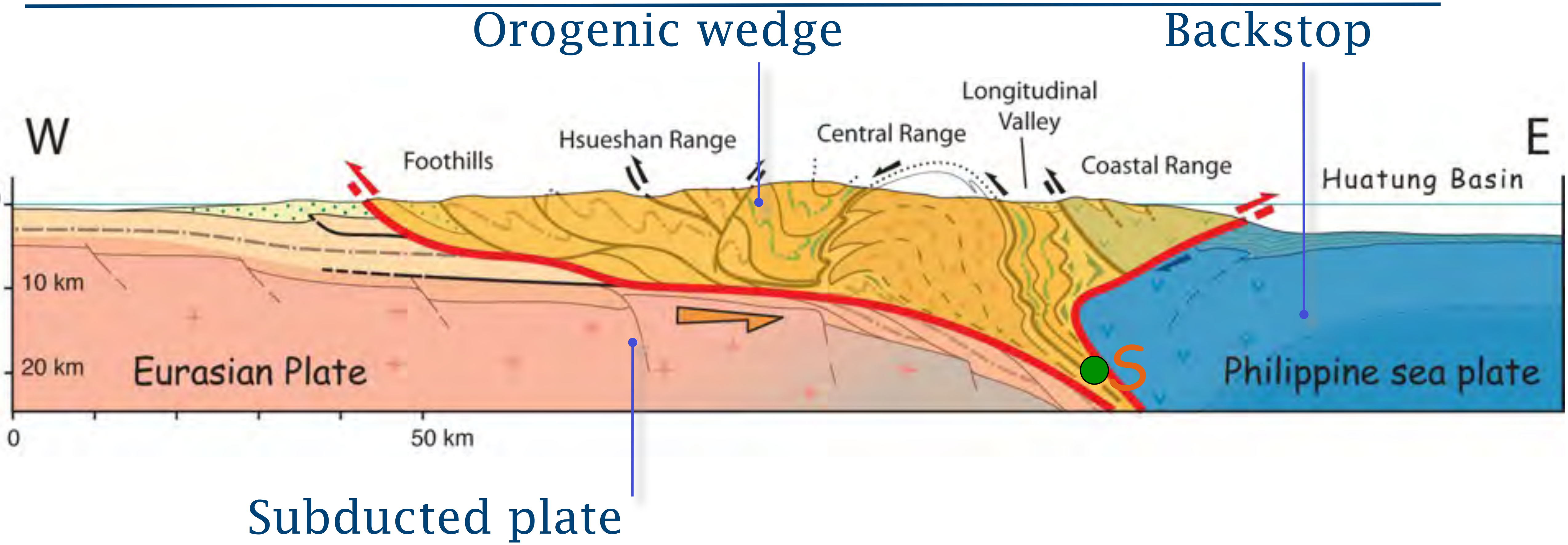


Seismicity around Taiwan

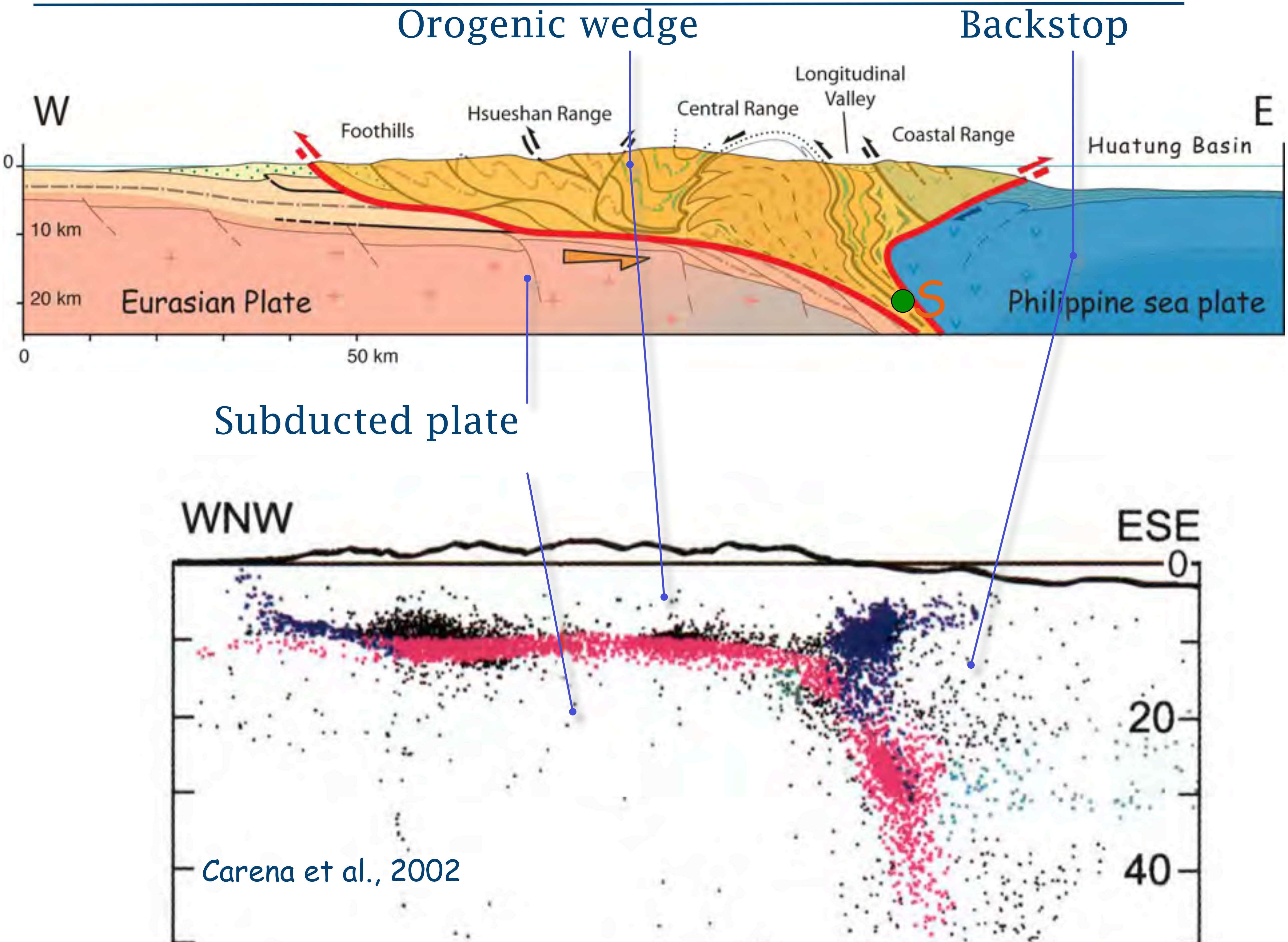


Carena et al., 2002

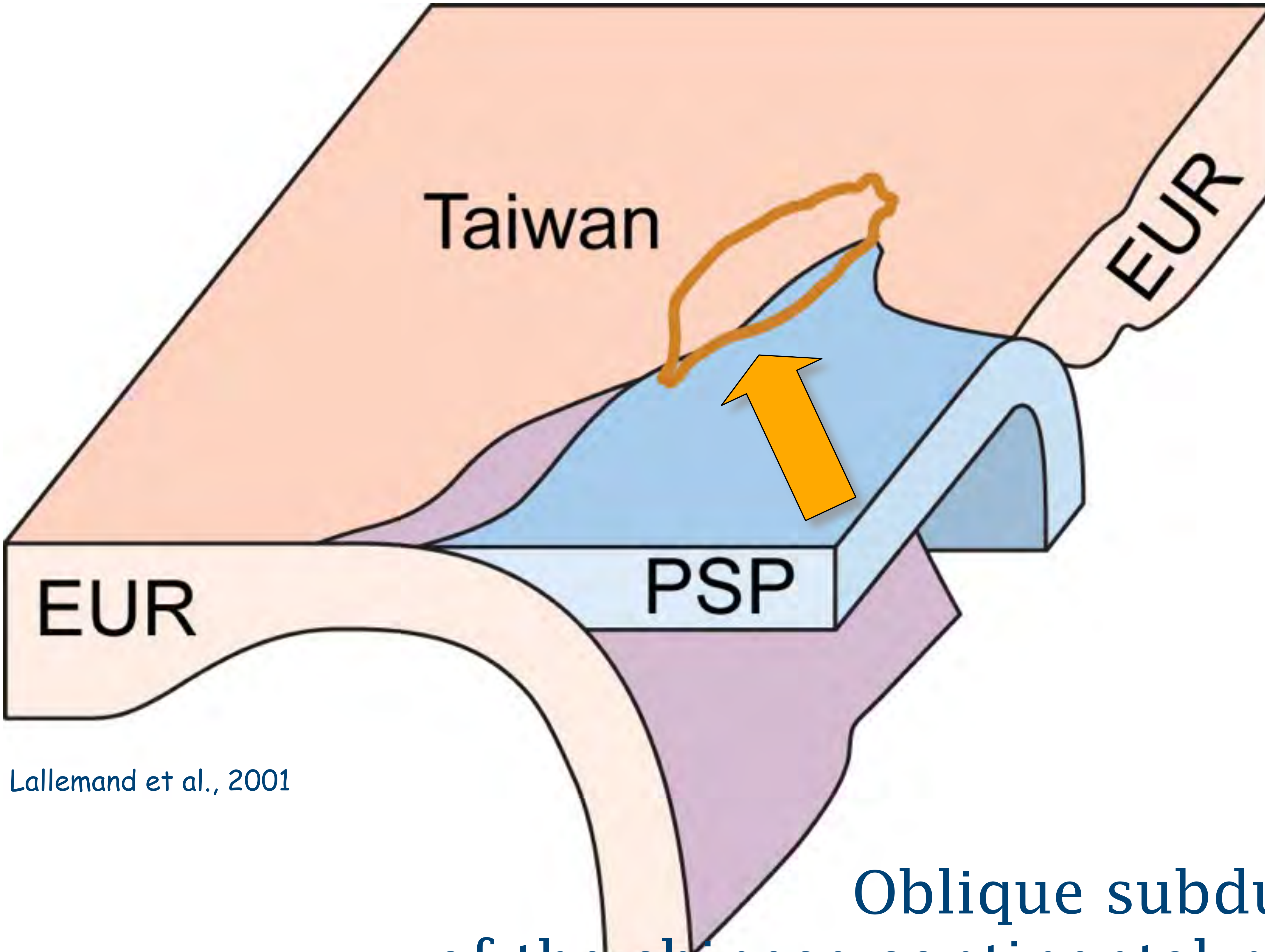
Taiwan's wedge geometry



Taiwan's wedge geometry



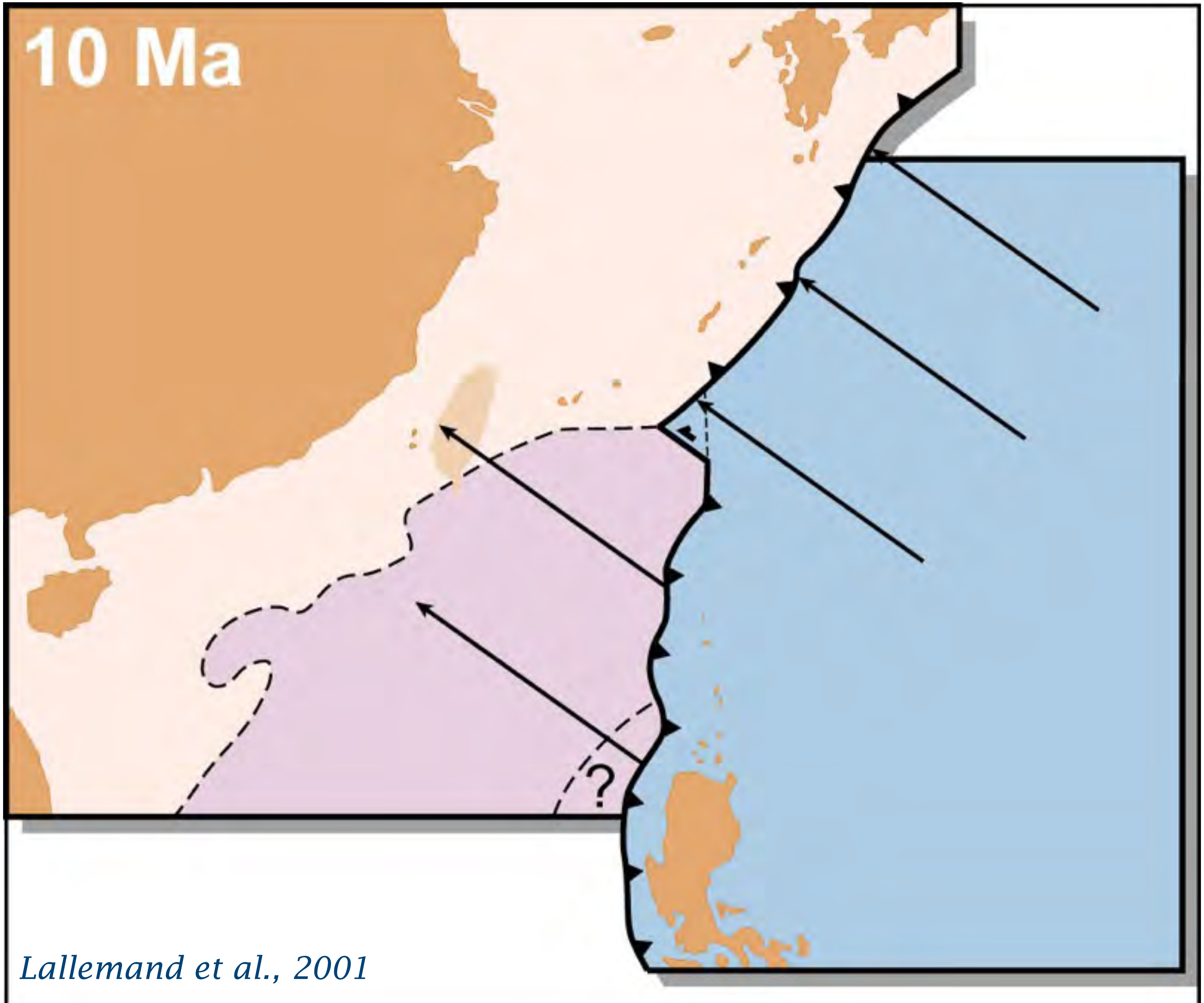
3D geometry



Lallemand et al., 2001

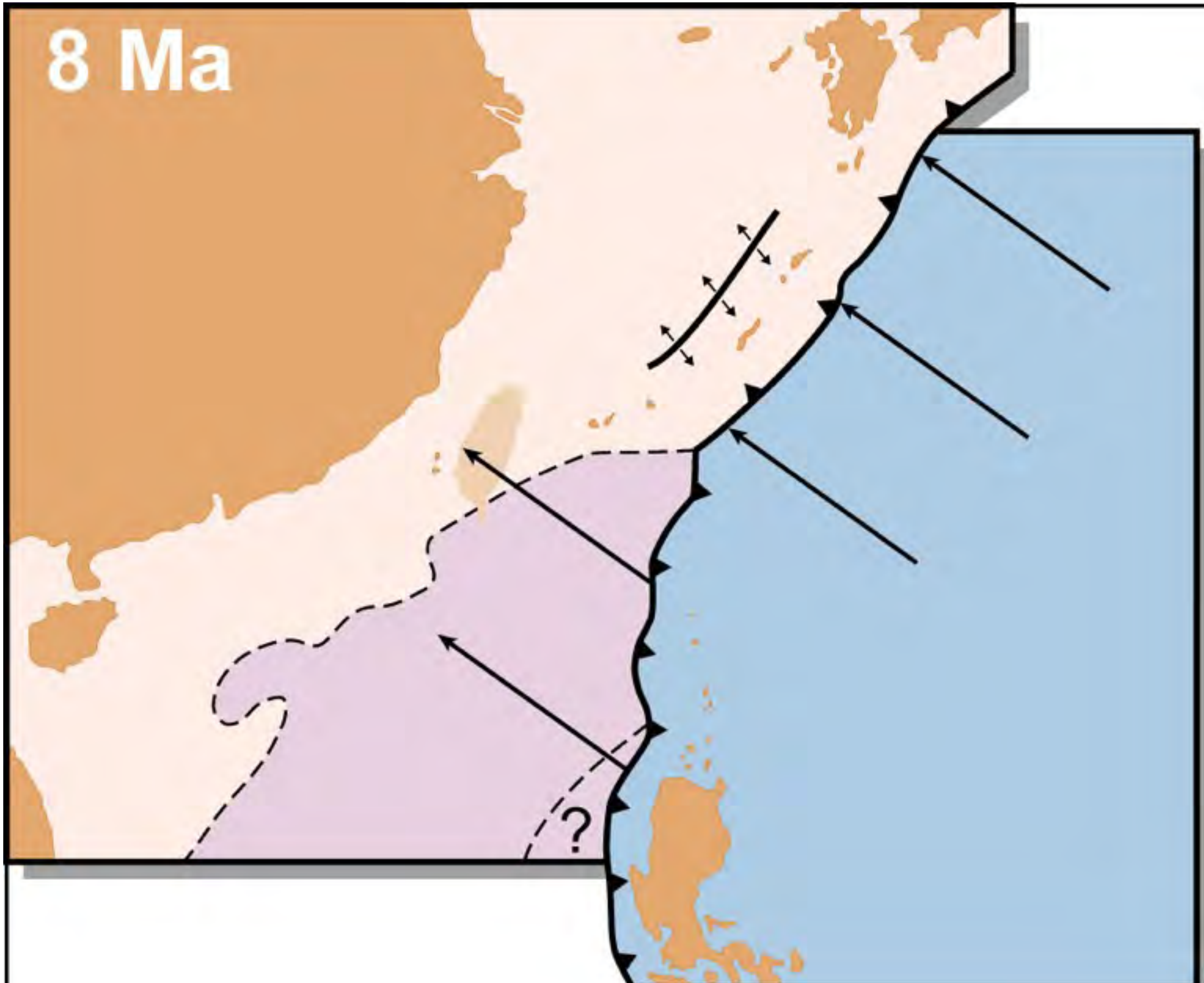
Oblique subduction
of the chinese continental margin
under the Philippine plate

Taiwan: geodynamic evolution



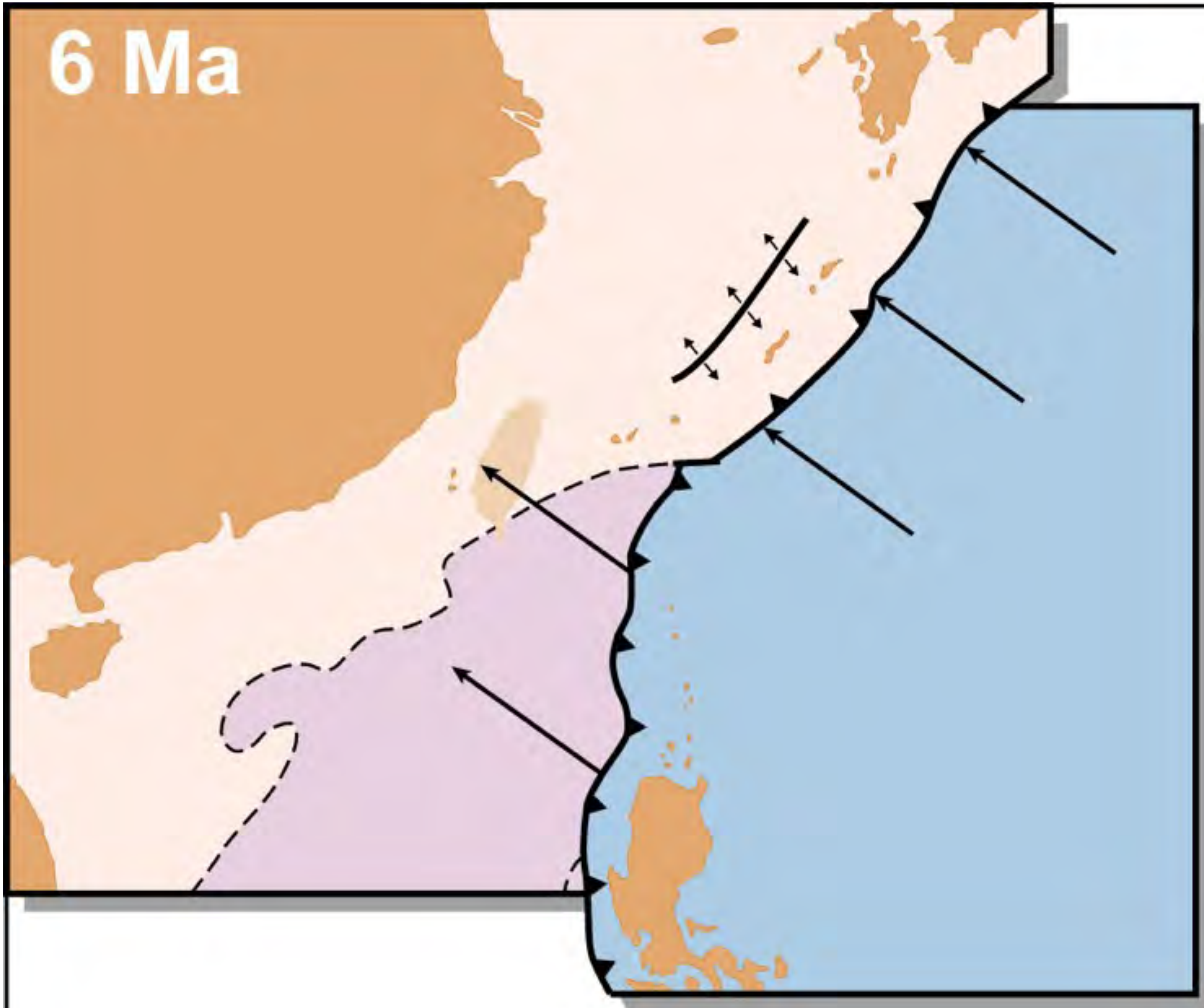
Lallemand et al., 2001

Taiwan: geodynamic evolution



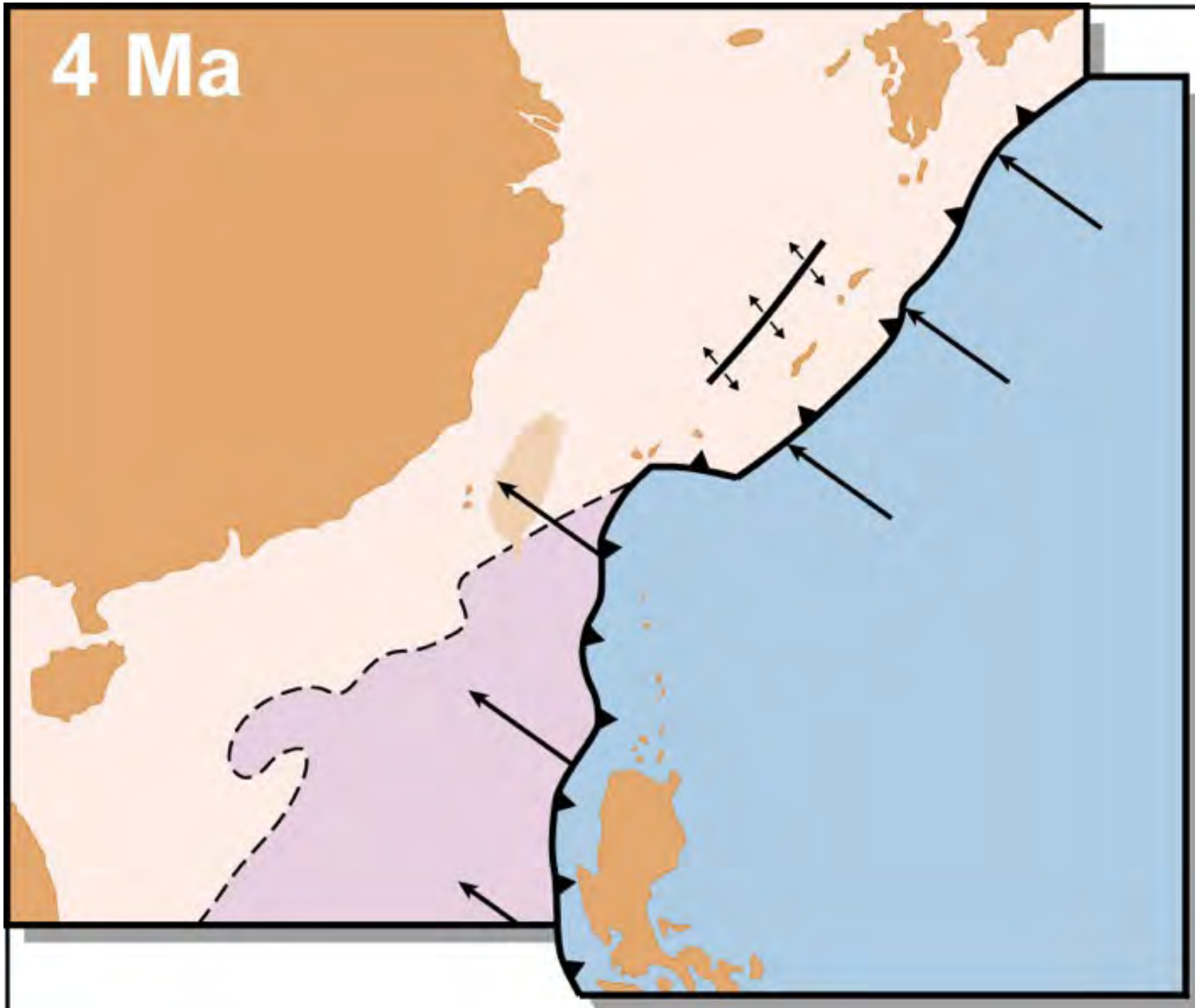
Lallemand et al., 2001

Taiwan: geodynamic evolution



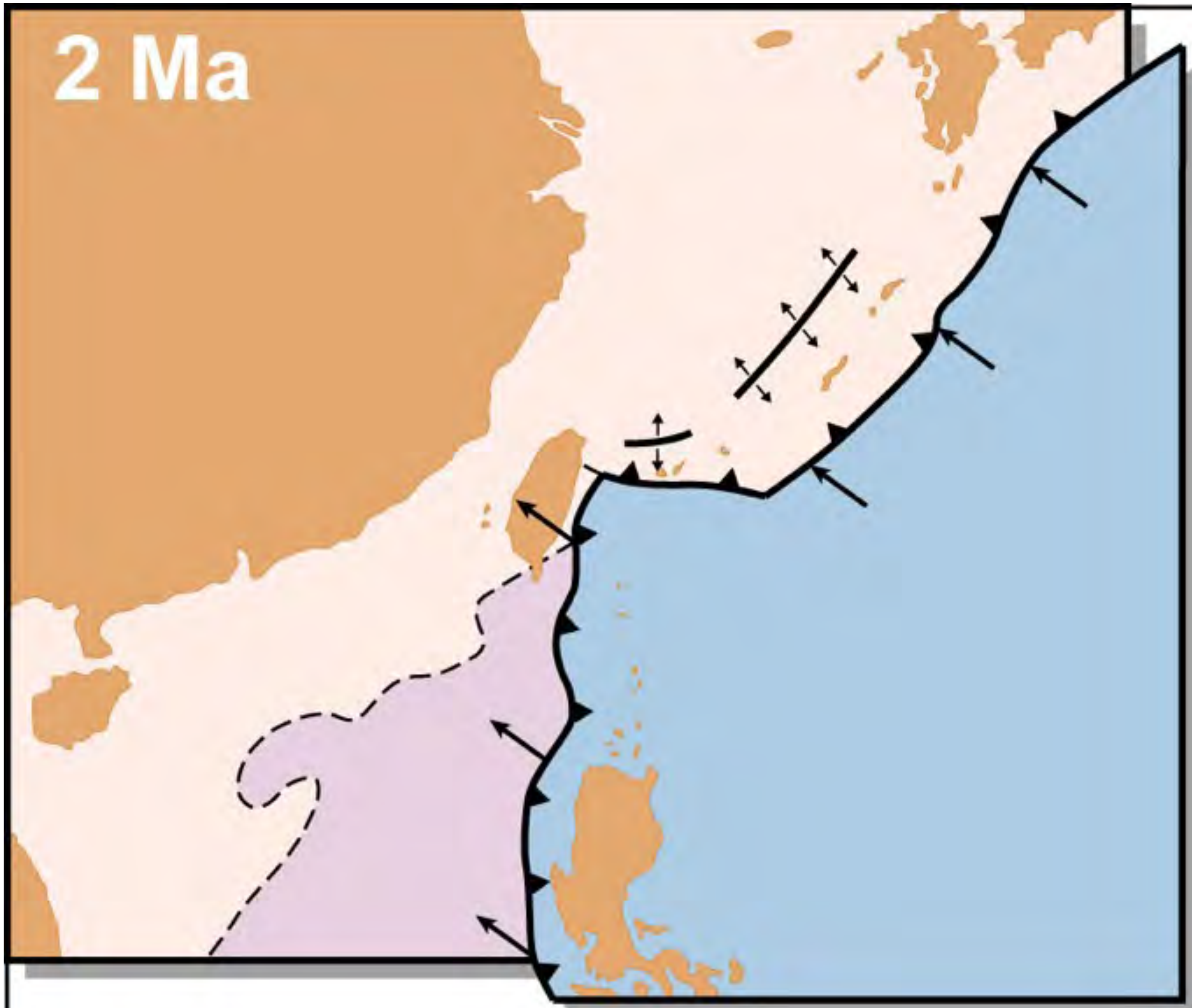
Lallemand et al., 2001

Taiwan: geodynamic evolution



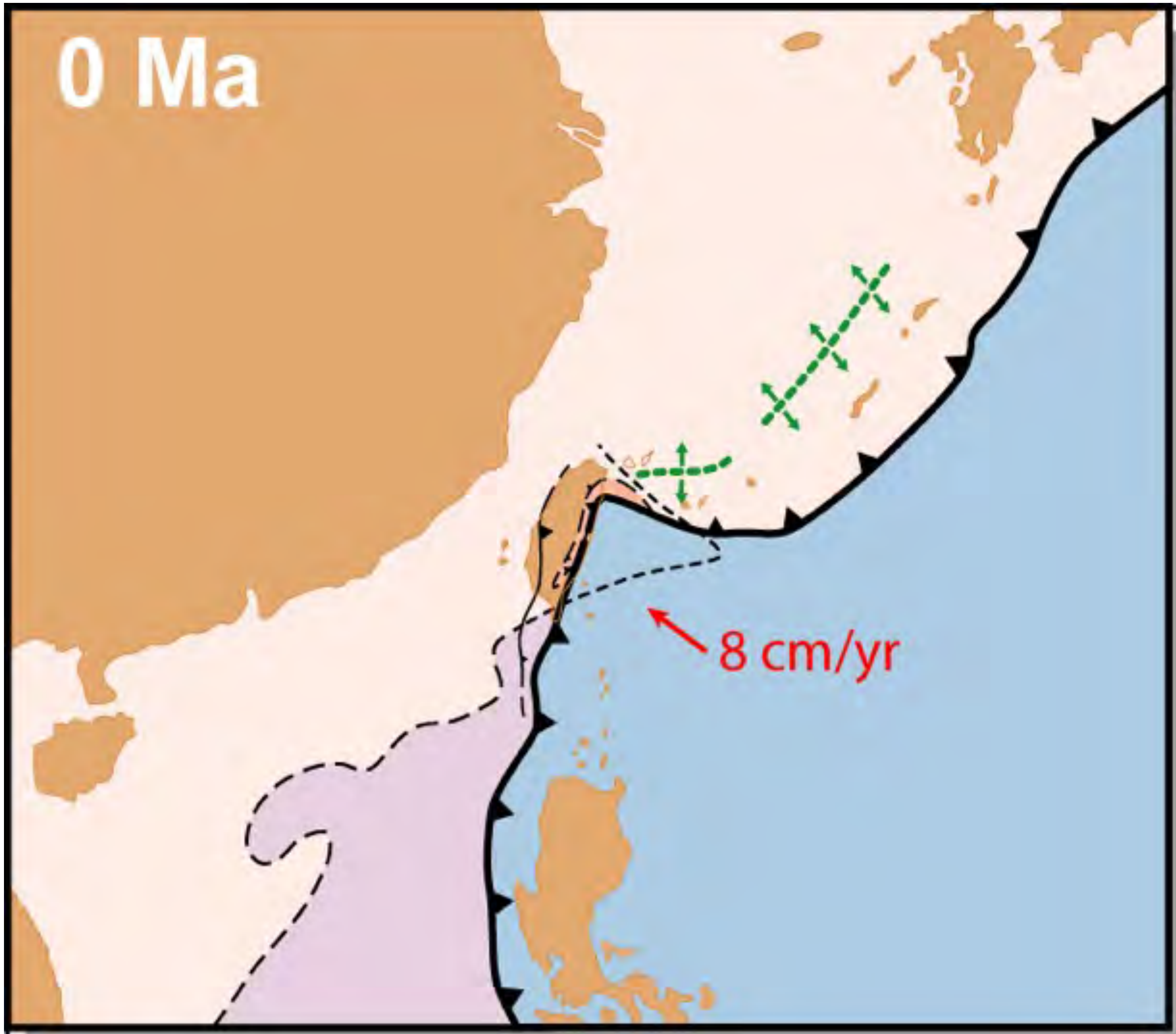
Lallemand et al., 2001

Taiwan: geodynamic evolution

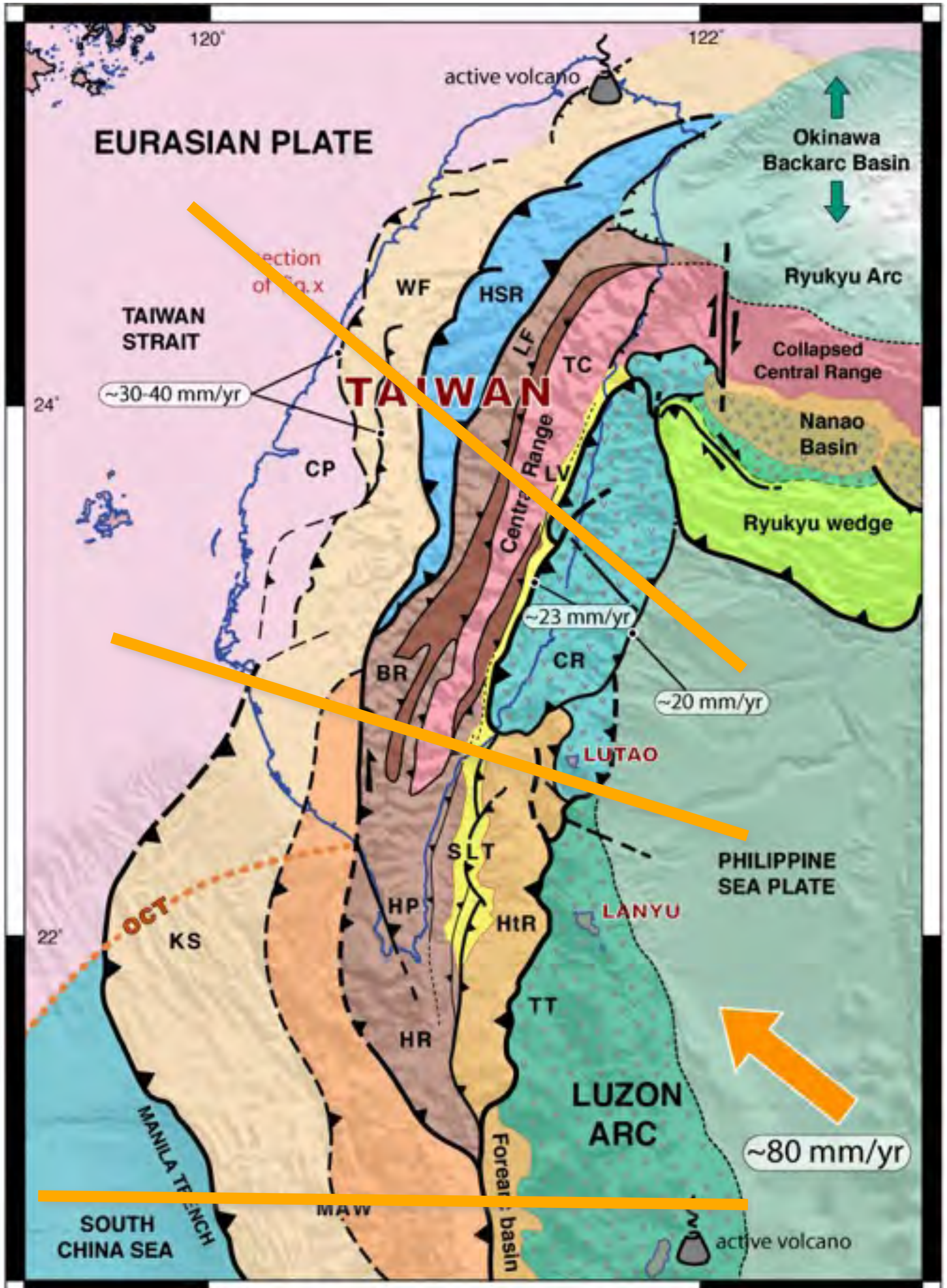


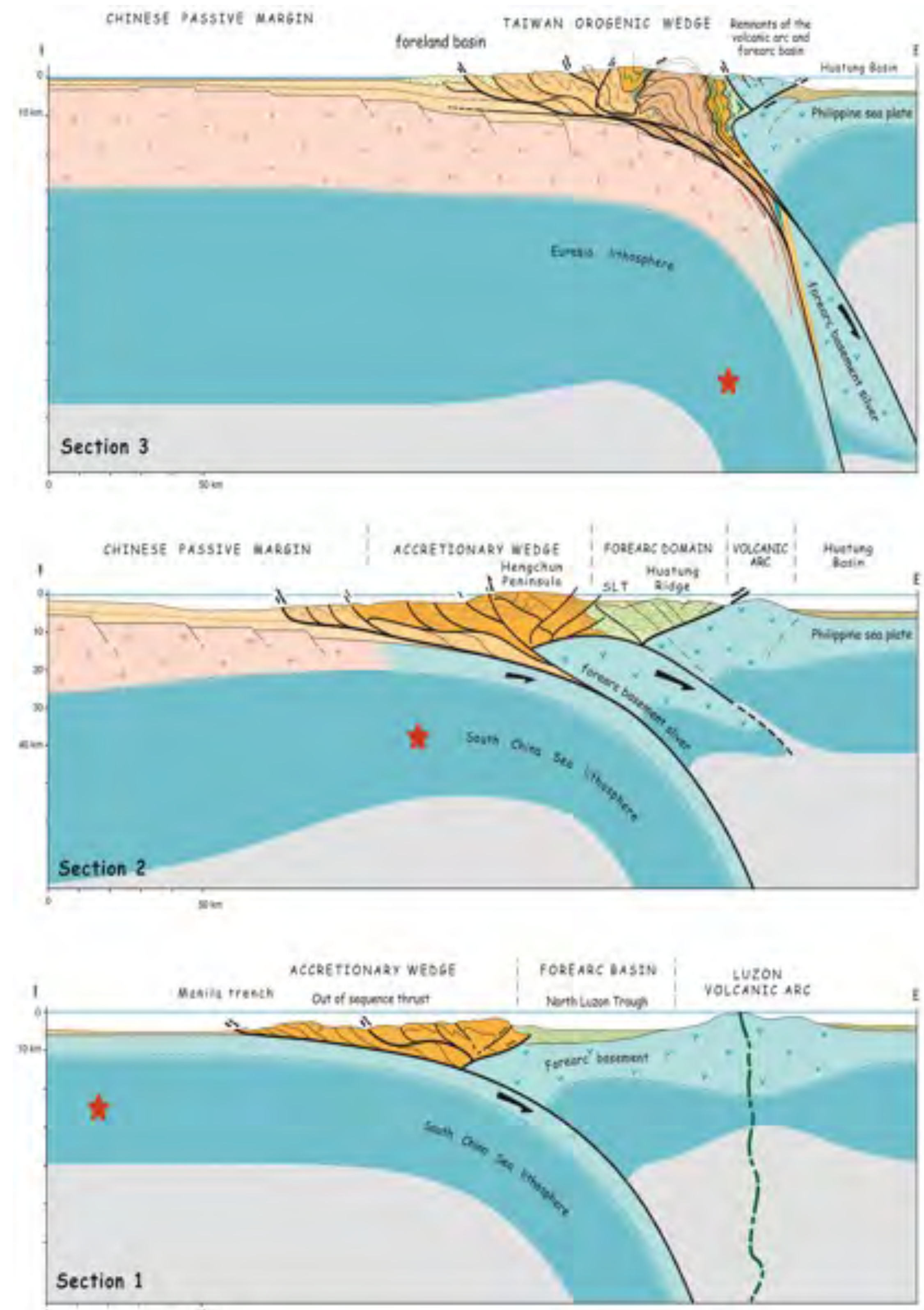
Lallemand et al., 2001

Taiwan: geodynamic evolution



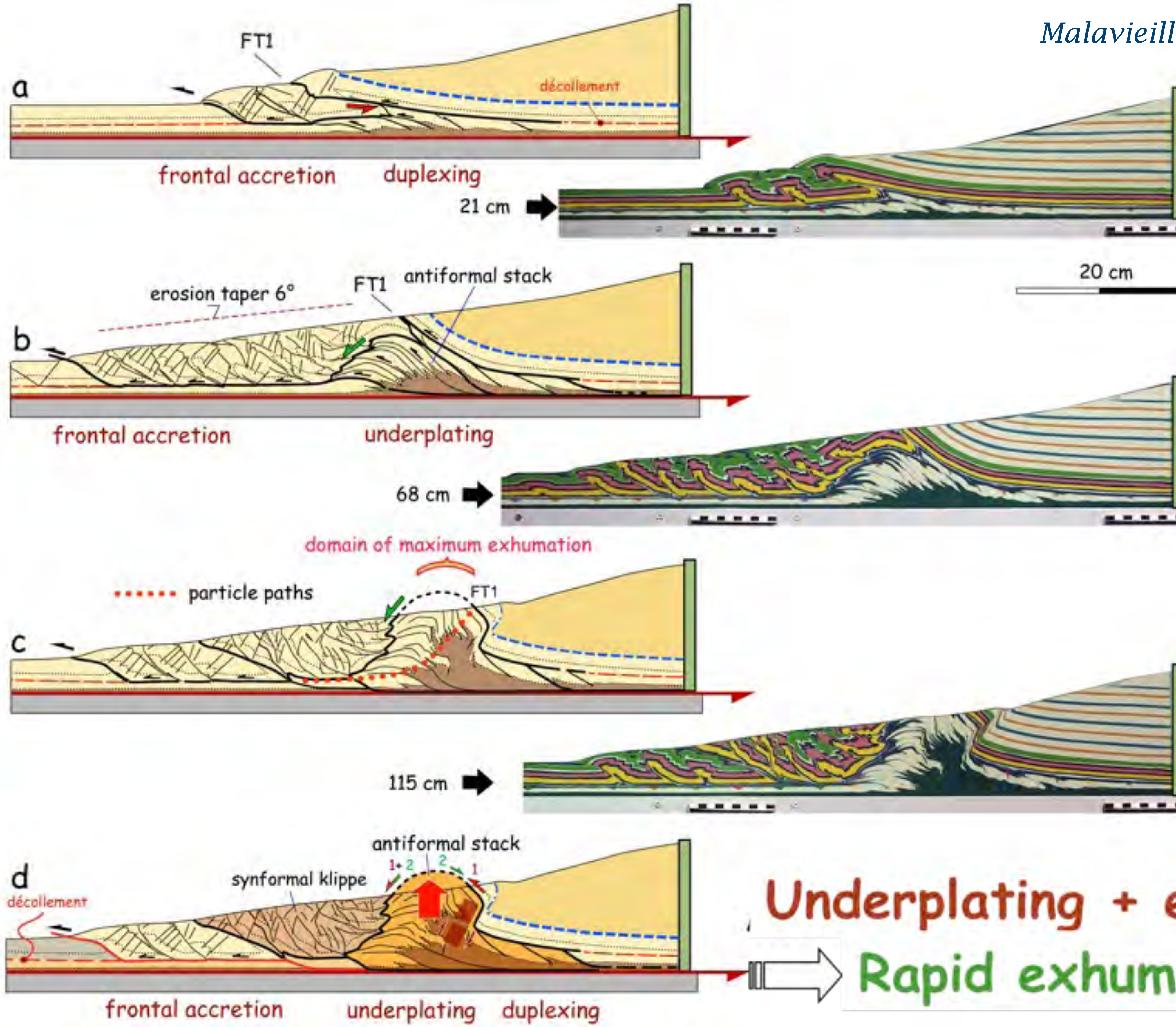
Lallemand et al., 2001


120°
122°
active volcano
EURASIAN PLATE
Okinawa
Backarc Basin
Ryukyu Arc
Collapsed
Central Range
Nanao
Basin
Ryukyu wedge
TAIWAN
STRAIT
~30-40 mm/yr
TAIWAN
WF
HSR
LF
TC
CP
Central Range
LV
BR
~23 mm/yr
CR
~20 mm/yr
LUTAO
PHILIPPINE
SEA PLATE
SLT
HP
HtR
LANYU
OCT
KS
TT
HR
LUZON
ARC
~80 mm/yr
MANILA TRENCH
MAW
Forearc basin
SOUTH
CHINA SEA
active volcano
24°
22°


CHINESE PASSIVE MARGIN
foreland basin
TAIWAN OROGENIC WEDGE
Section 3
CHINESE PASSIVE MARGIN
ACCRETIONARY WEDGE
FOREARC DOMAIN
VOLCANIC ARC
Section 2
ACCRETIONARY WEDGE
FOREARC BASIN
LUZON VOLCANIC ARC
Manila trench
Section 1

Taiwan: analogical models

Malavieille, com. pers.



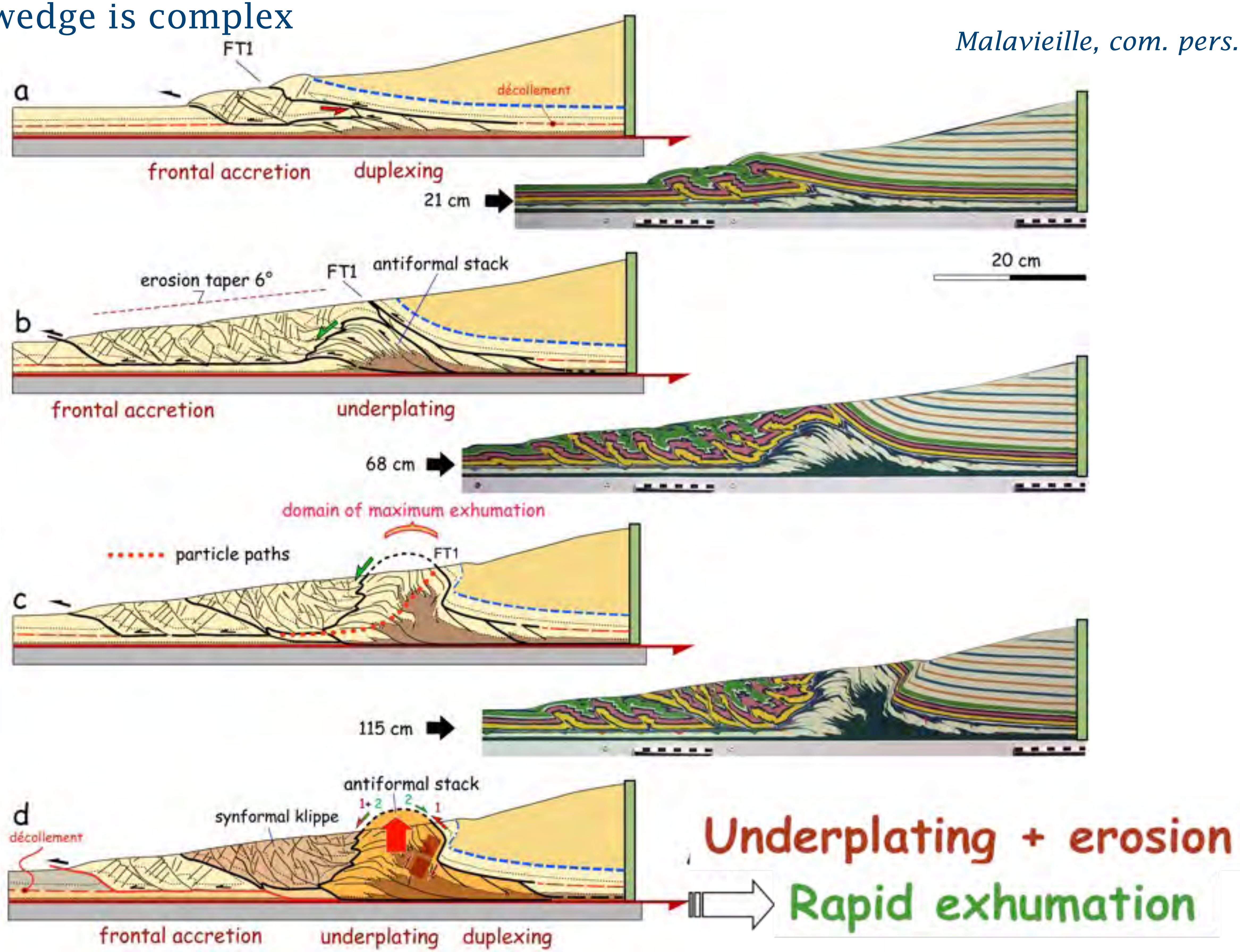
Underplating + erosion

Rapid exhumation

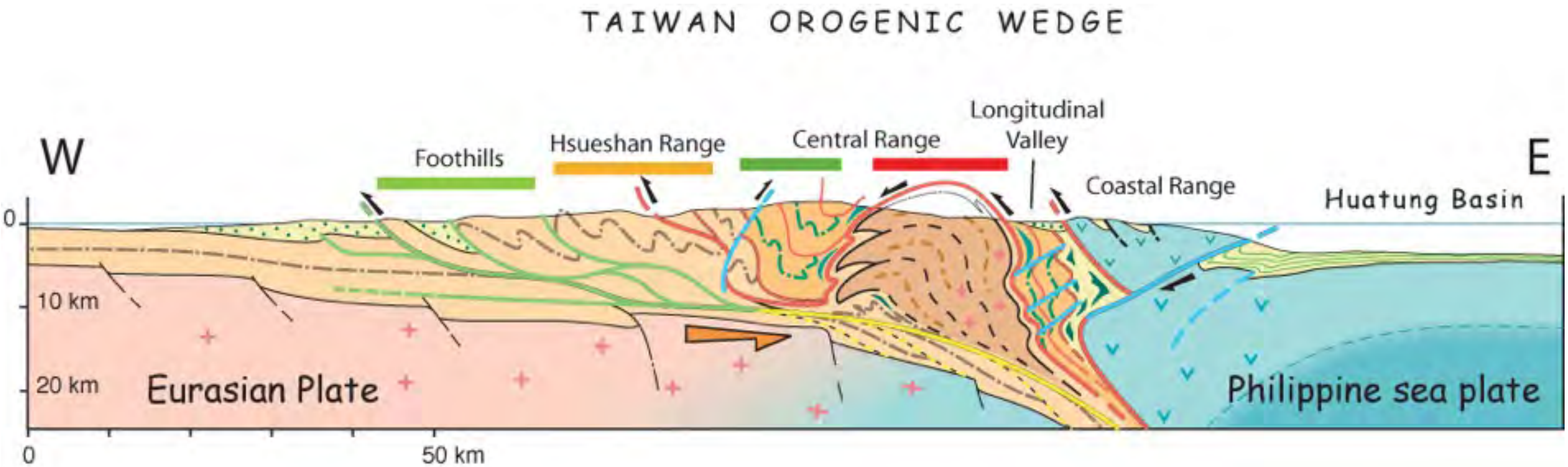
Taiwan: analogical models

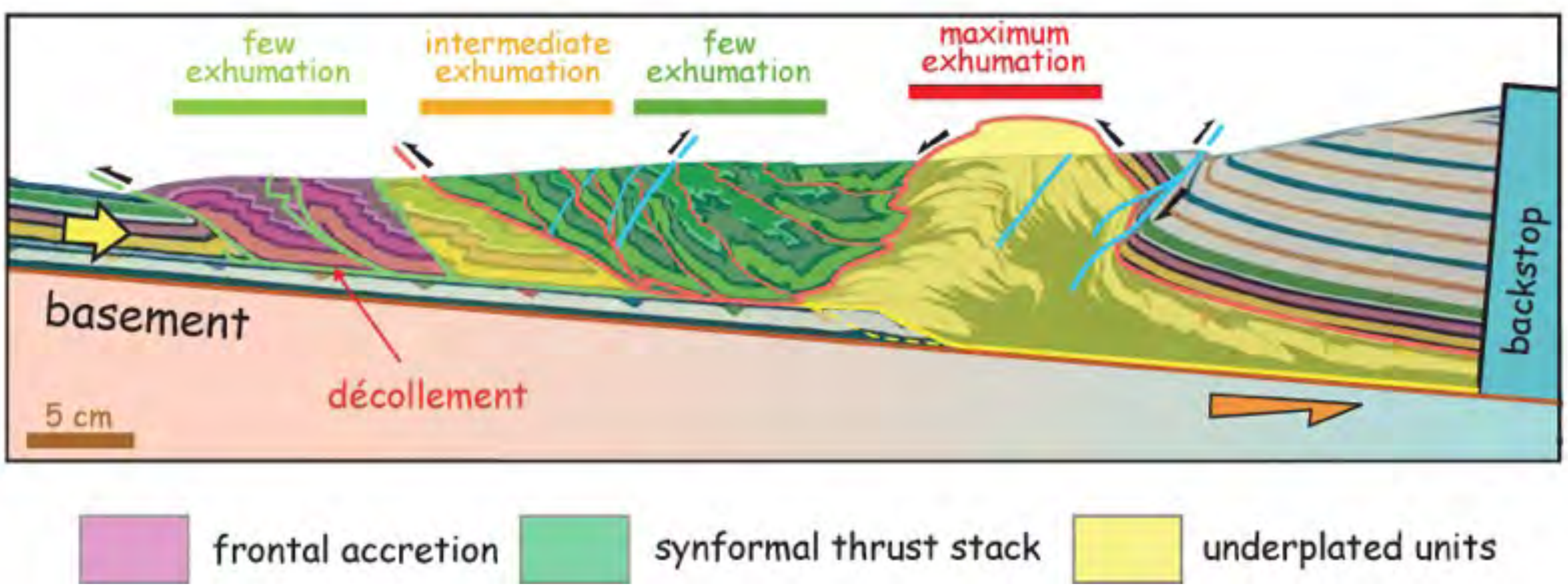
Although convergence & erosion being uniform, deformation recorded in the wedge is complex

Malavieille, com. pers.



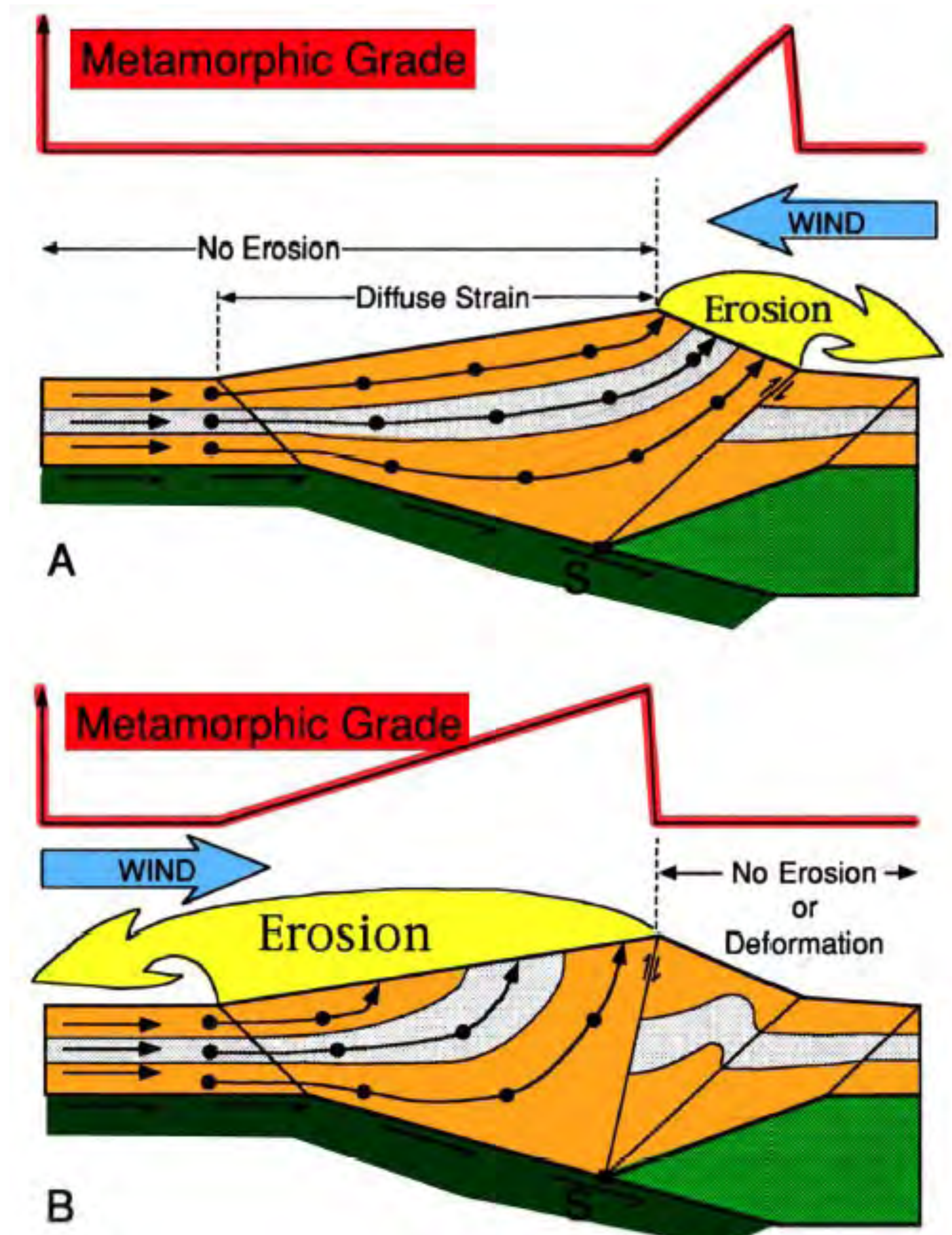
Taiwan: structure vs model



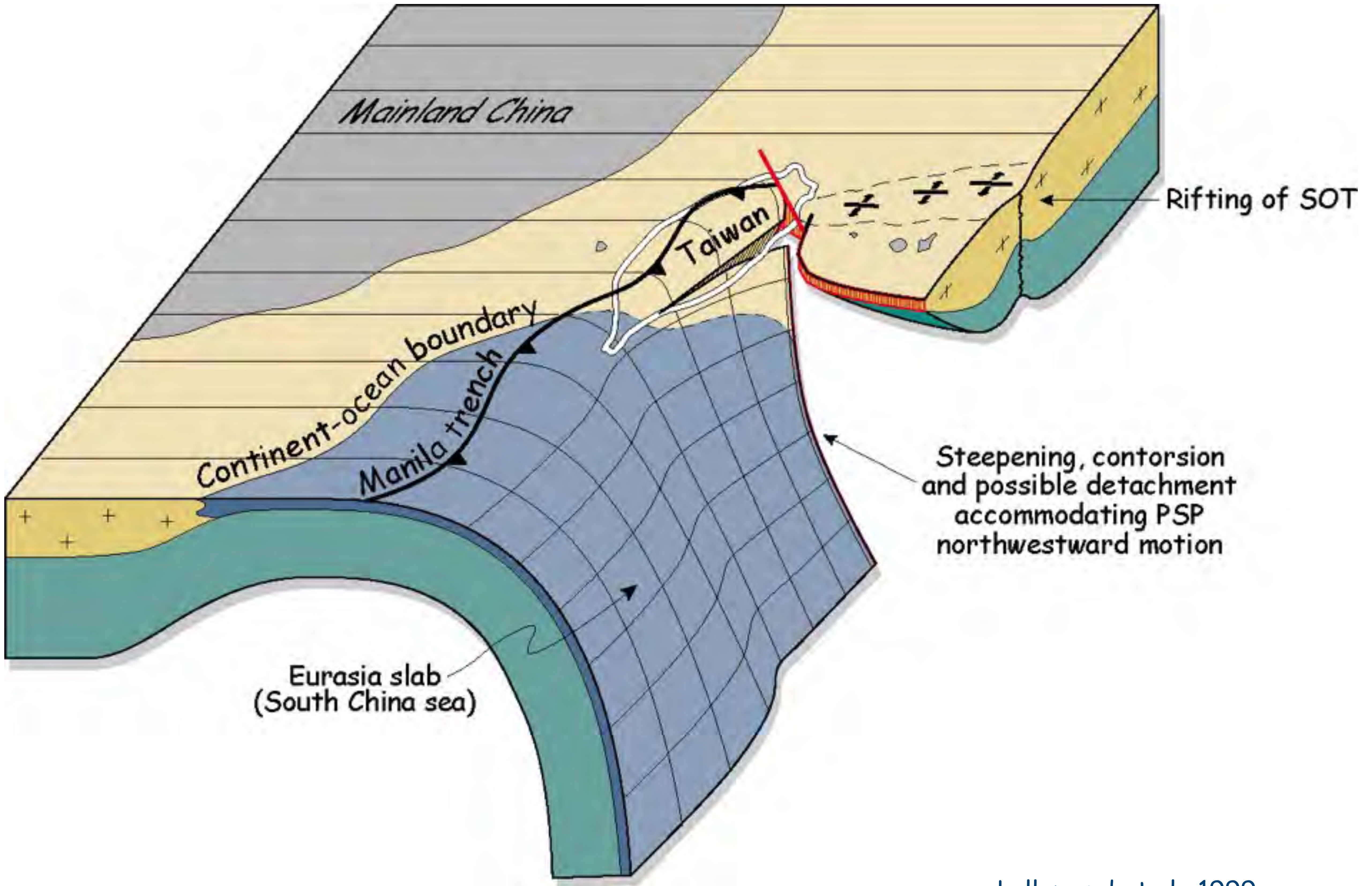


Malavieille, com. pers.

Metamorphic evolution & erosion distribution



Willett et al. 2001



Lallemand et al., 1999

Main forces of plate tectonics

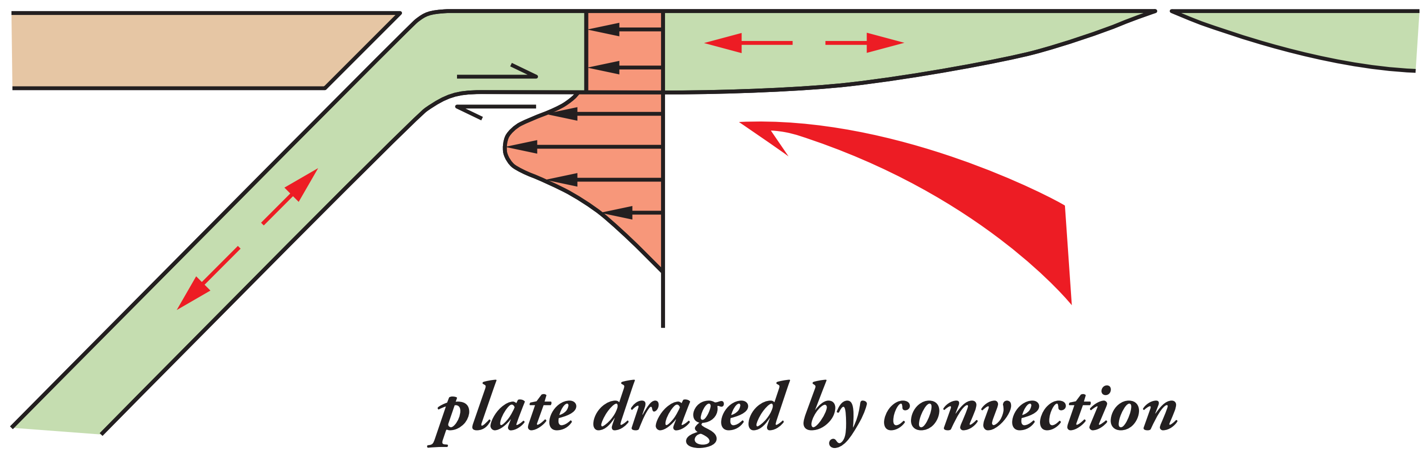


plate draged by convection

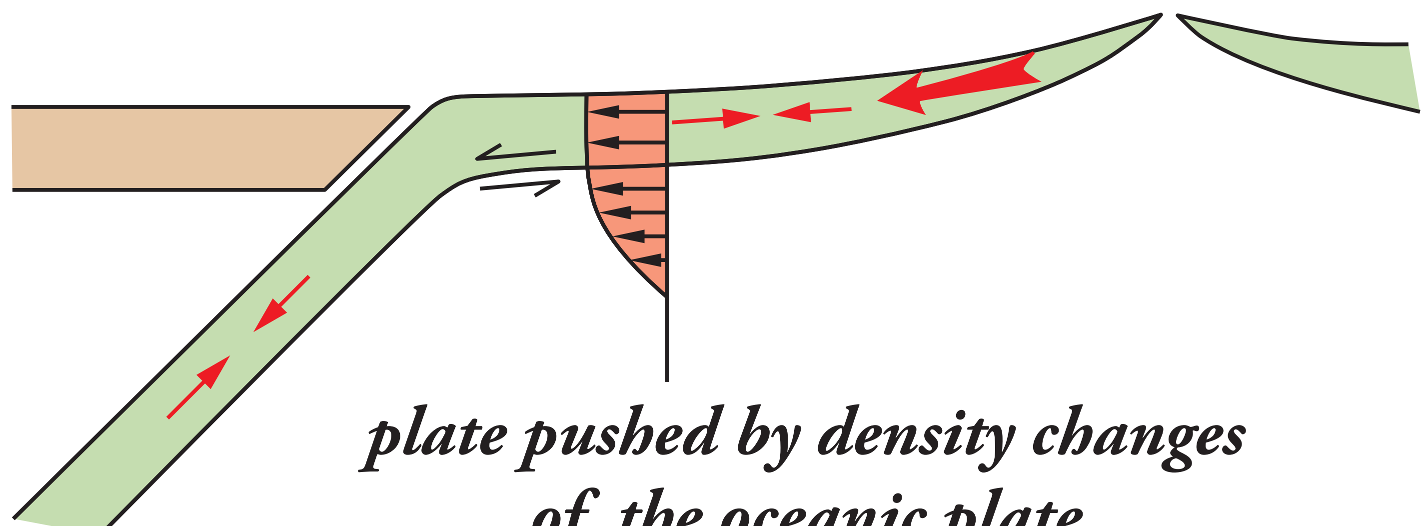


plate pushed by density changes of the oceanic plate

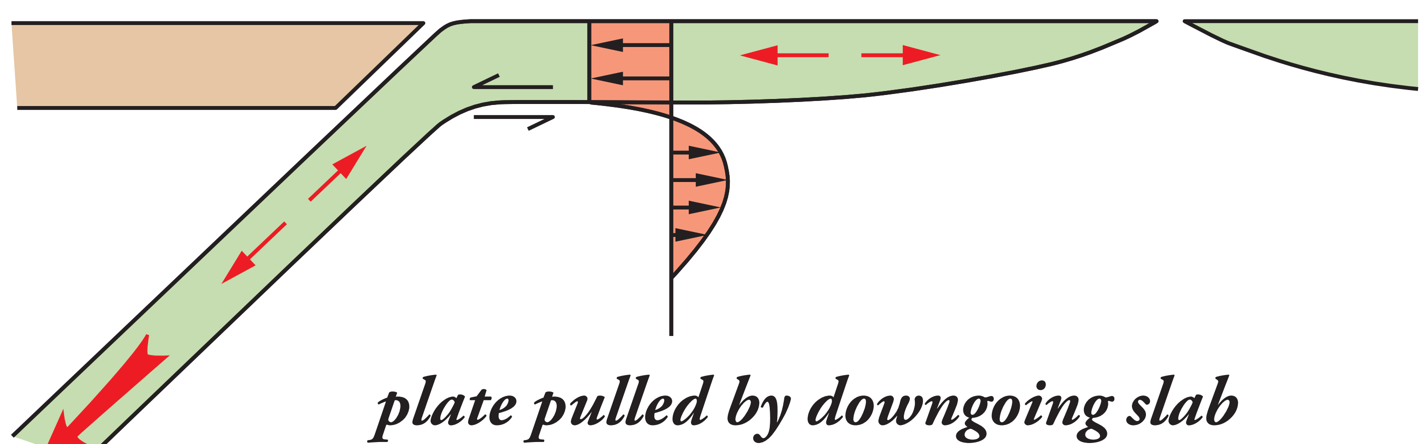
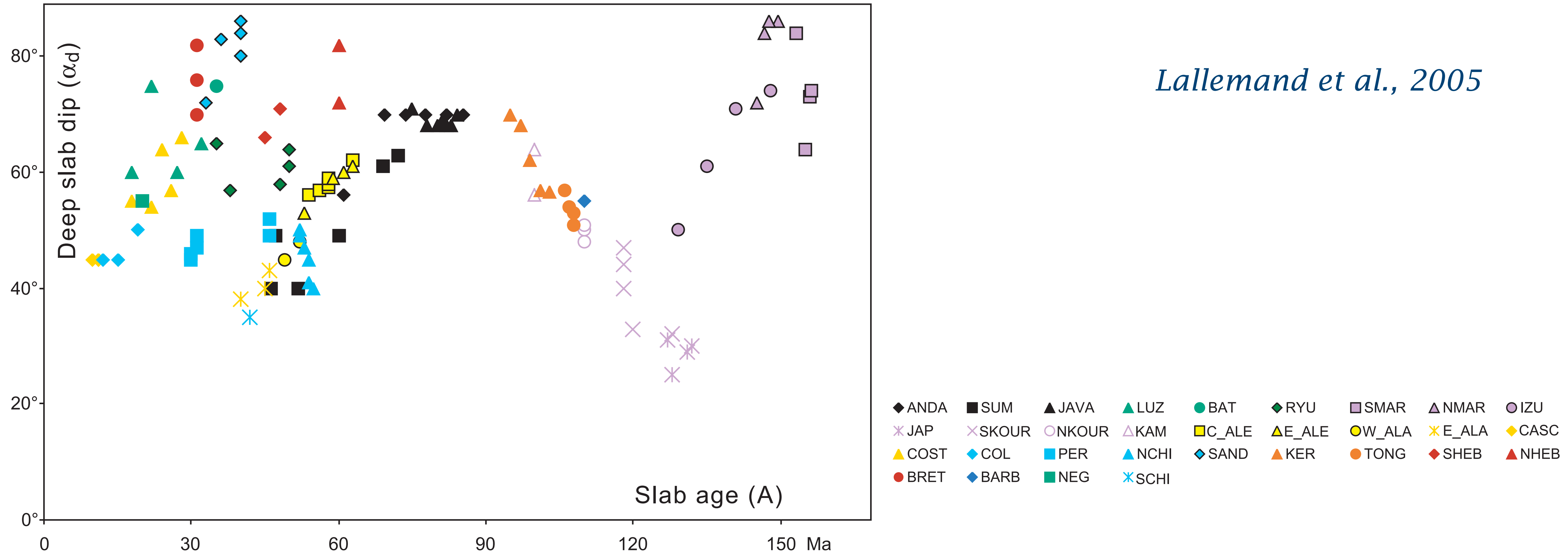
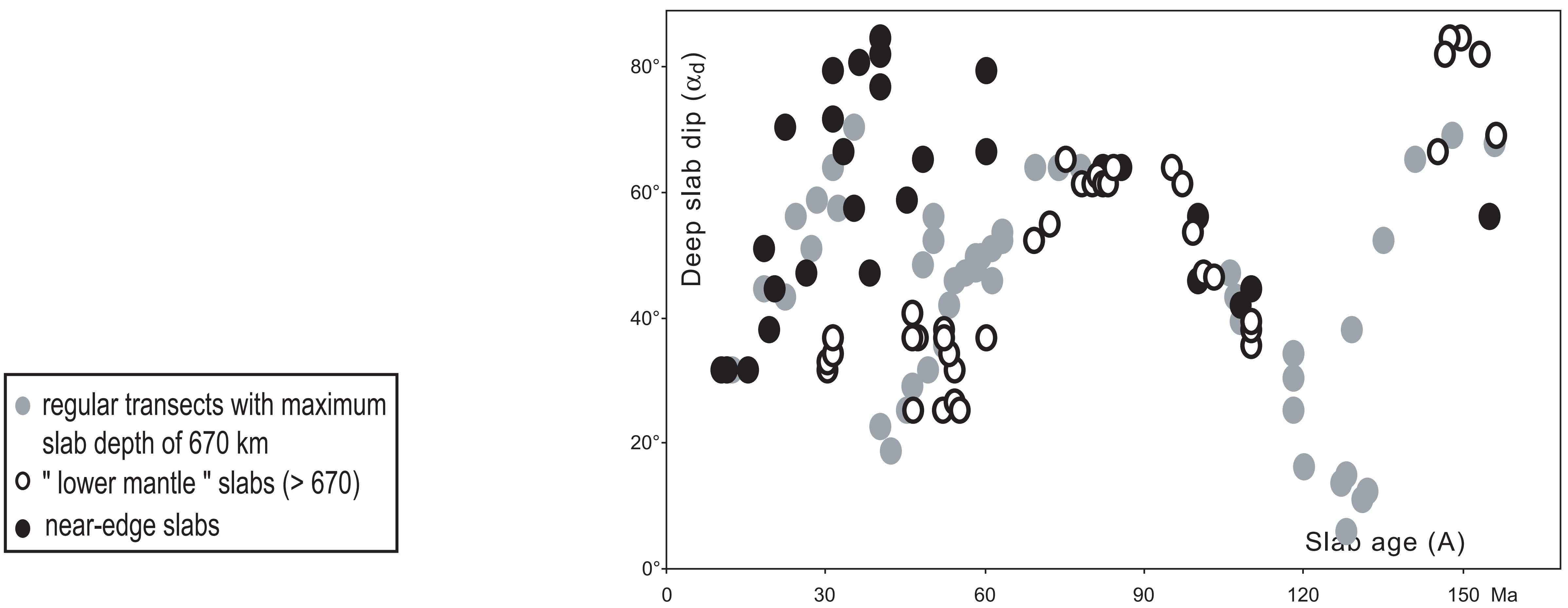


plate pulled by downgoing slab

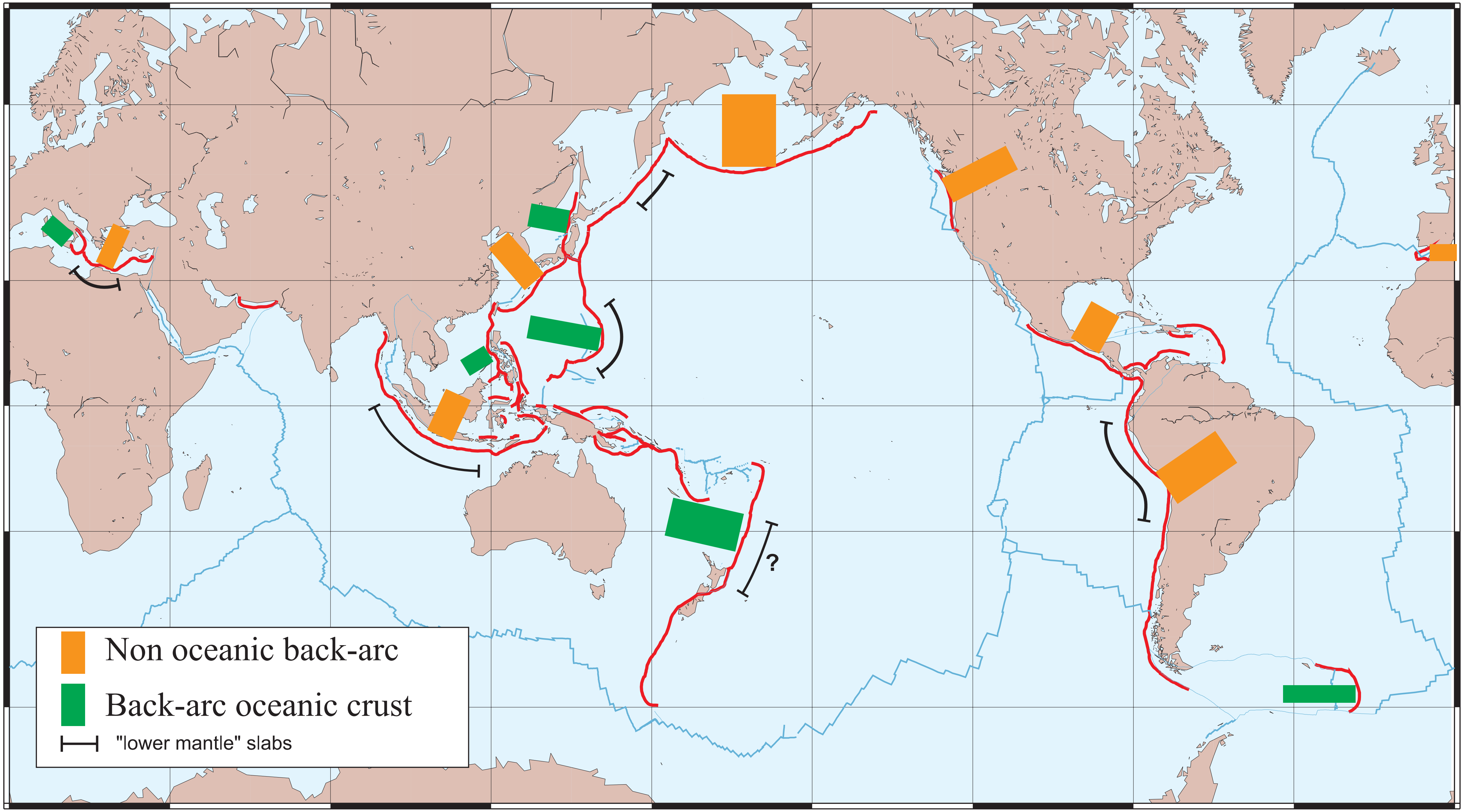
Slab dip vs. age

Lallemand et al., 2005

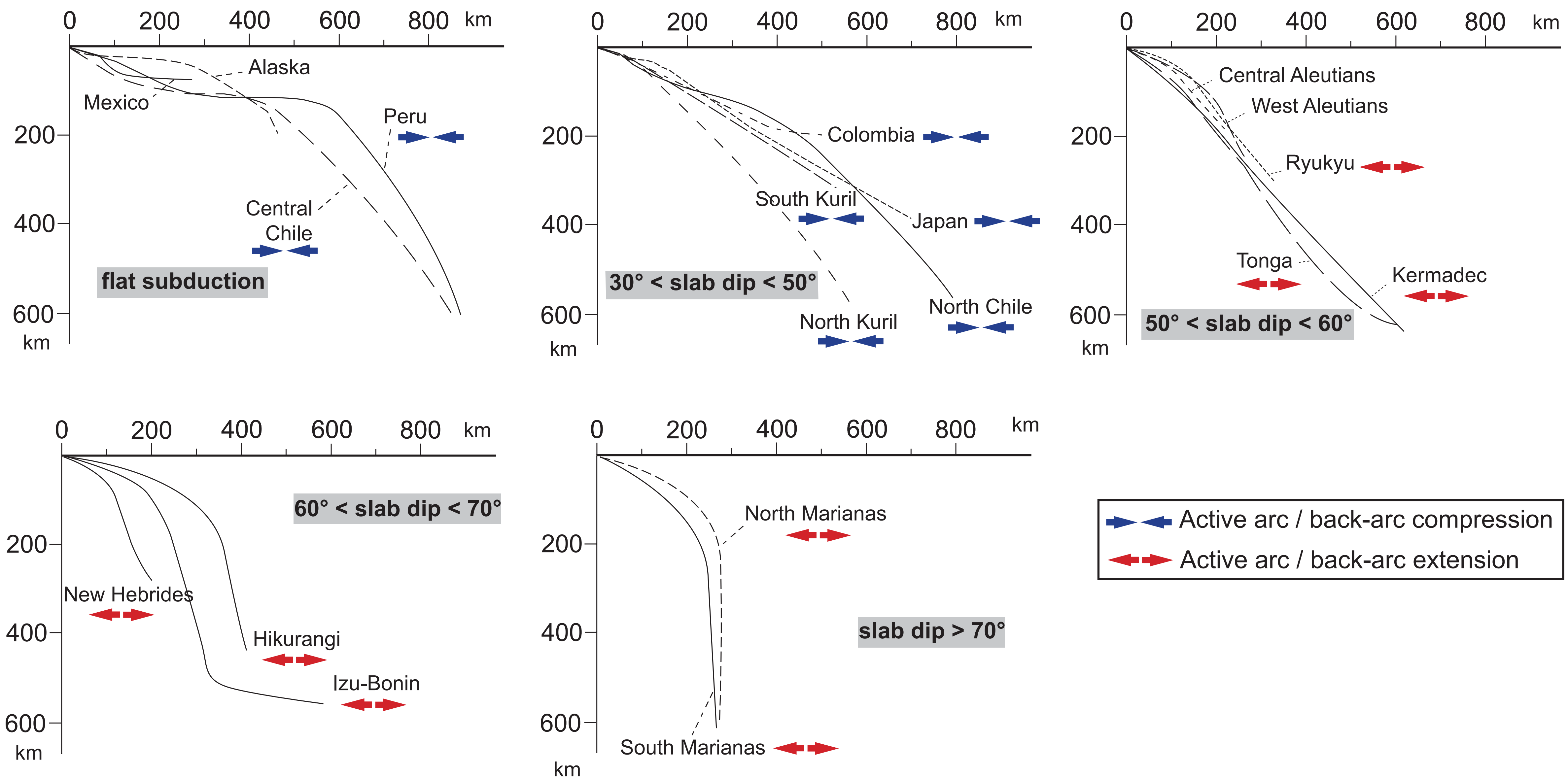




Back-arc dynamics



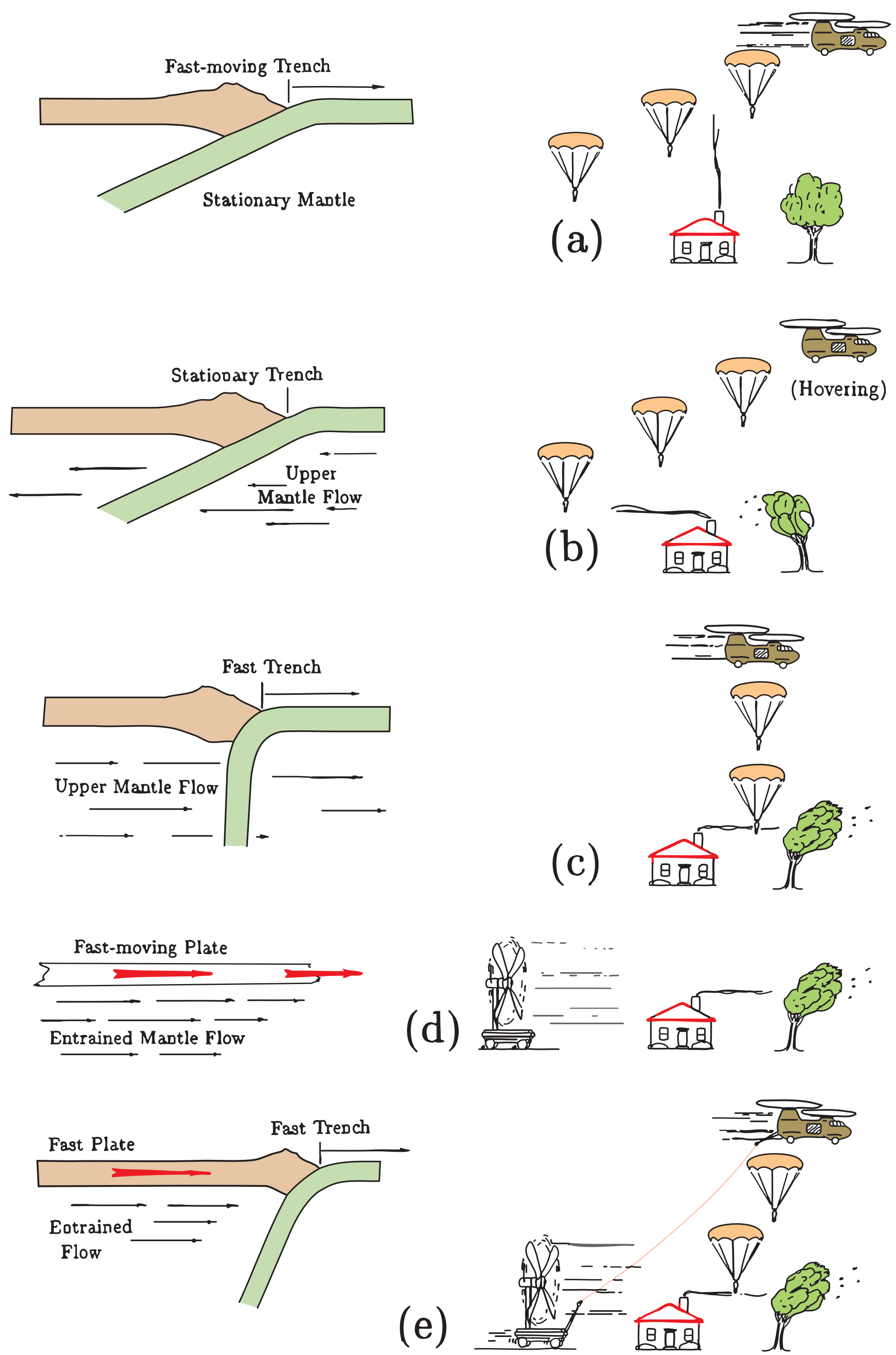
Back-arc dynamics



Major Pacific slab geometries classified by groups of deep slab dips except the first group, which concerns flat subductions with variable deep slab dips: 30° to 50°, 50° to 60°, 60° to 70°, steeper than 70°. Active arc/ back-arc compression is observed for slab dips lower than 50°, whereas active arc/ back-arc extension occurs only for slabs dips steeper than 50°.

Absolute *vs* effective trench migration

The shape produced by sinking slab elements depends upon the speed of the trench relative to the underlying mantle



Similar profiles may result from
(a) a fast trench and quiescent mantle or

(b) a stationary trench and a fast flowing upper mantle; in both cases the effective migration rate is the same. Even in the absence of the global mantle flow, this coupling will result in steeper dips than produced in a.

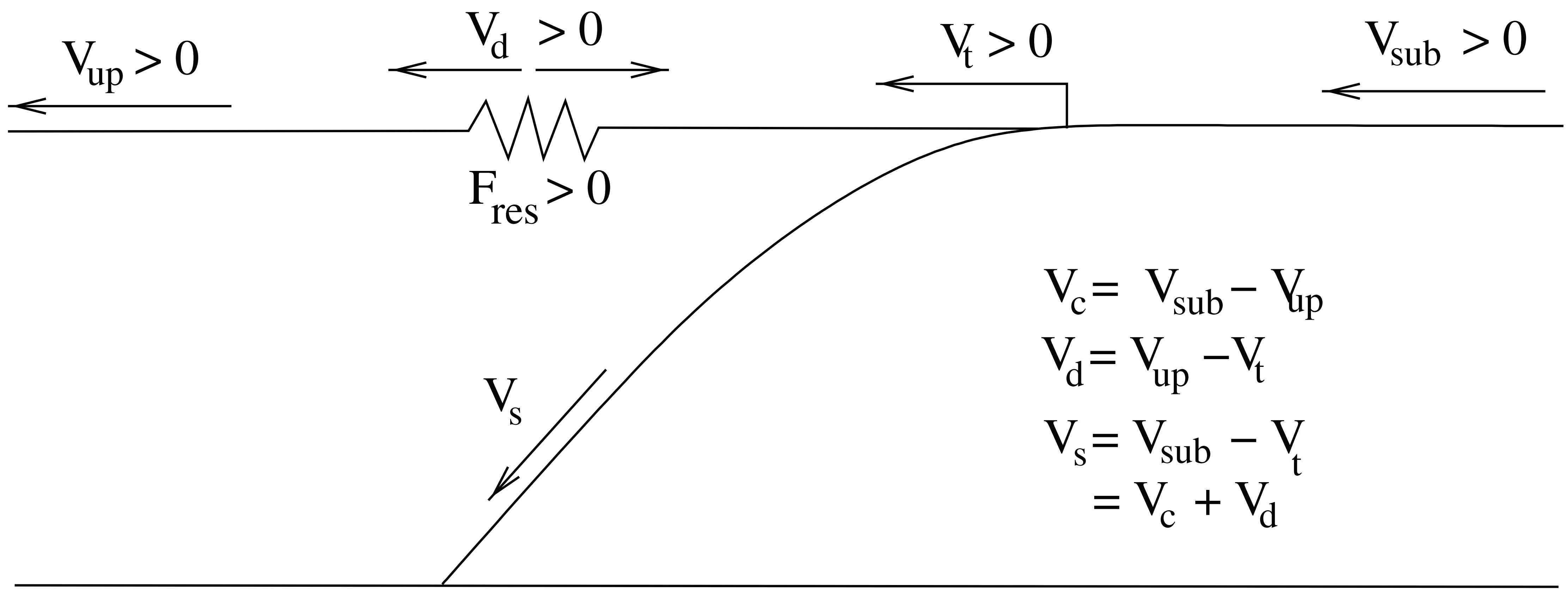
(c) **Conversely**, a fast moving trench may have zero effective velocity.

(d) Plate motions alter mantle flow fields unless completely decoupled.

(e) In one-sided subduction, plate/mantle coupling will generate a flow associated with the trench's motion, thus limiting changes in effective migration.

Tao & O'Connell, 1992

Relative motions of subduction zones



Arcay et al., 2008

Relative motions of subduction zones

Arcay et al., 2008

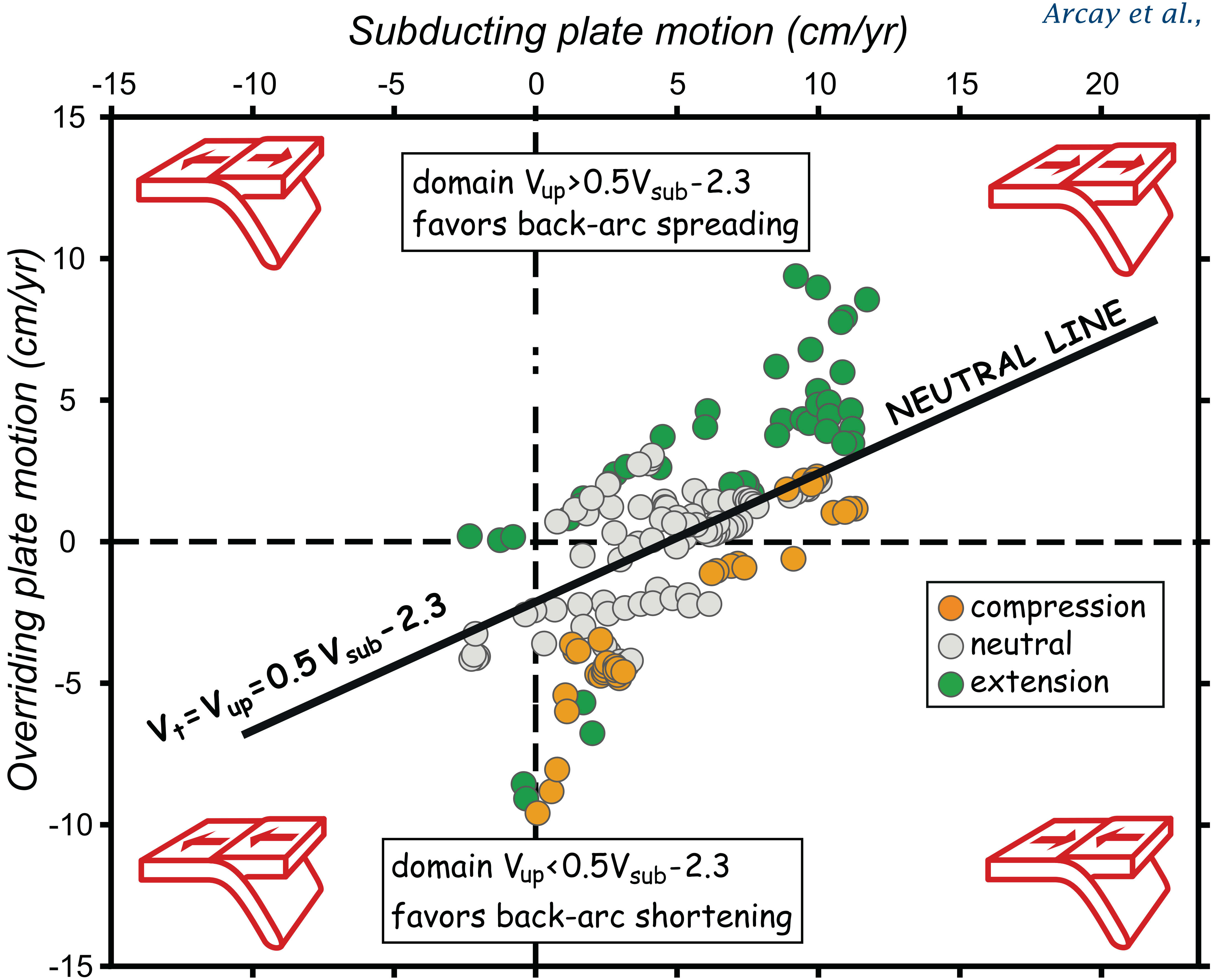


Plate tectonic forces