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A comparison of numerical and analogue models of subduction initiation

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HORIZON 2020

"The method is not important.
The scientific question is what matters."

Jean-Pierre Brun

Analogue, numerical, analytical

=

Methods

… not science

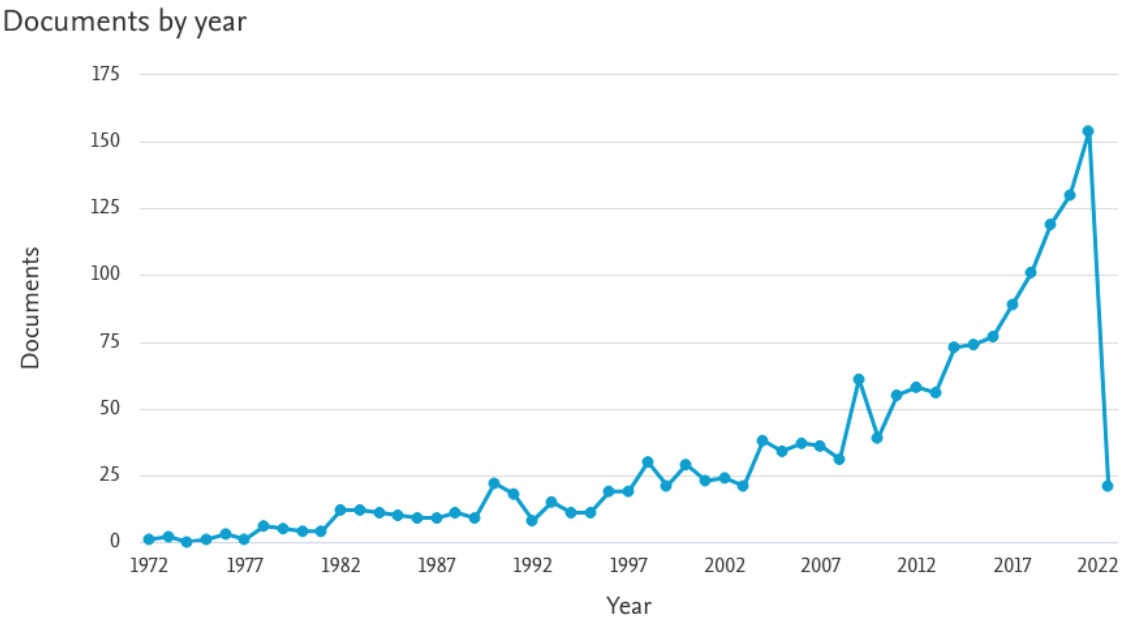
Research Focus: Subduction Initiation

TITLE-ABS-KEY (subduction AND initiation)

1,664 document results

Select year range to analyze: 1972 to 2022 Analyze

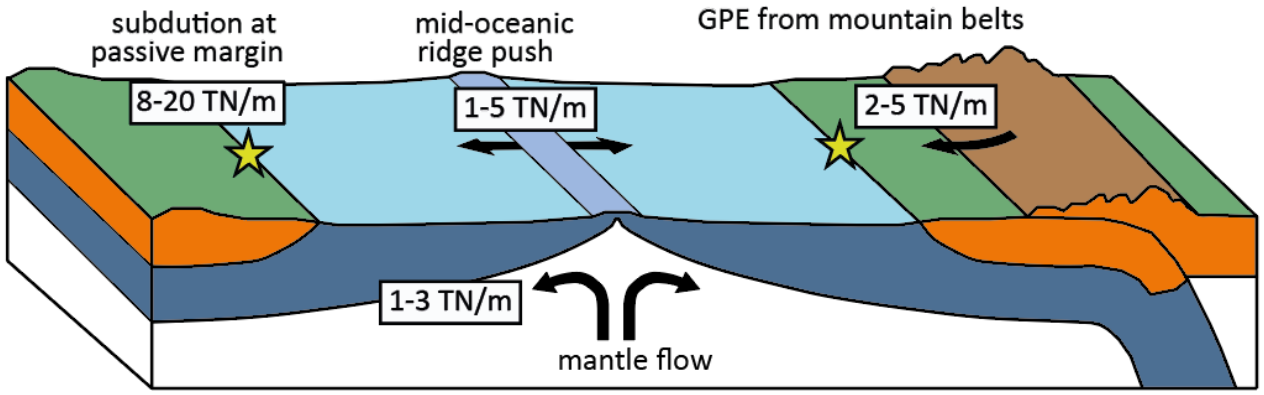
Year	Documents
2022	21
2021	154
2020	130
2019	119
2018	101
2017	89
2016	77
2015	74
2014	73
2013	56



SOURCE: SCOPUS

Subduction initiation: Spontaneous vs Induced

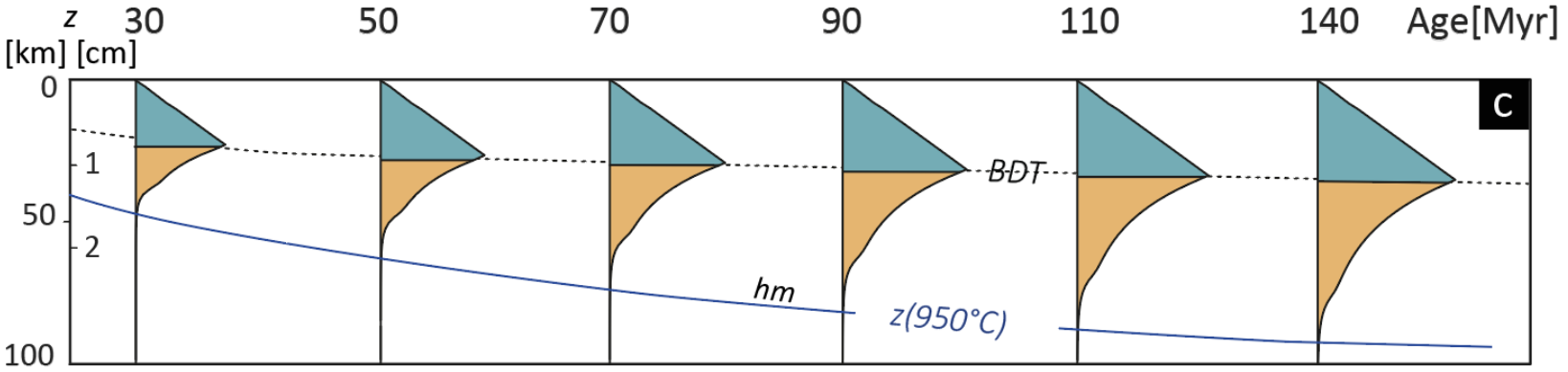
A problem of forces …



Subduction require compressional force of at least 7 x 10^{12} N/m

- Low mantle strength
- Low density

+ High mantle strength
+ High density



Cloetingh et al 1989 ; Mueller et al 1991

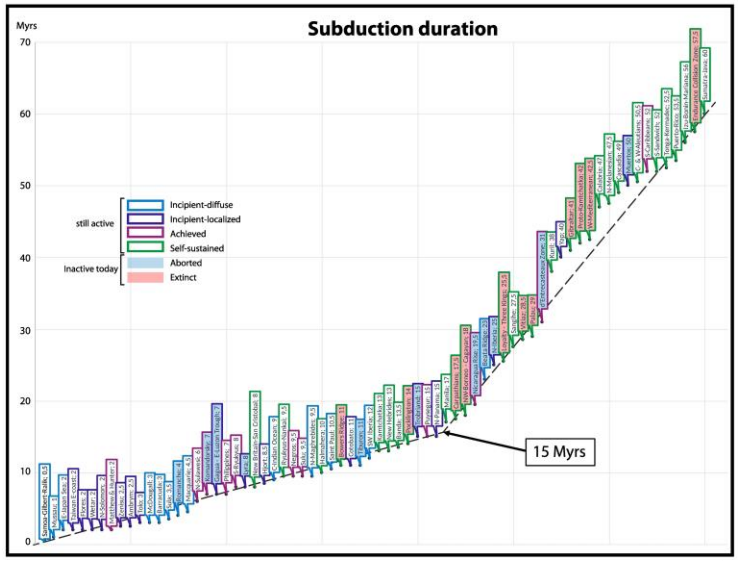
Where & When does Subduction initiate ?

Crameri et al, 2020; Ulvrova et al. 2019

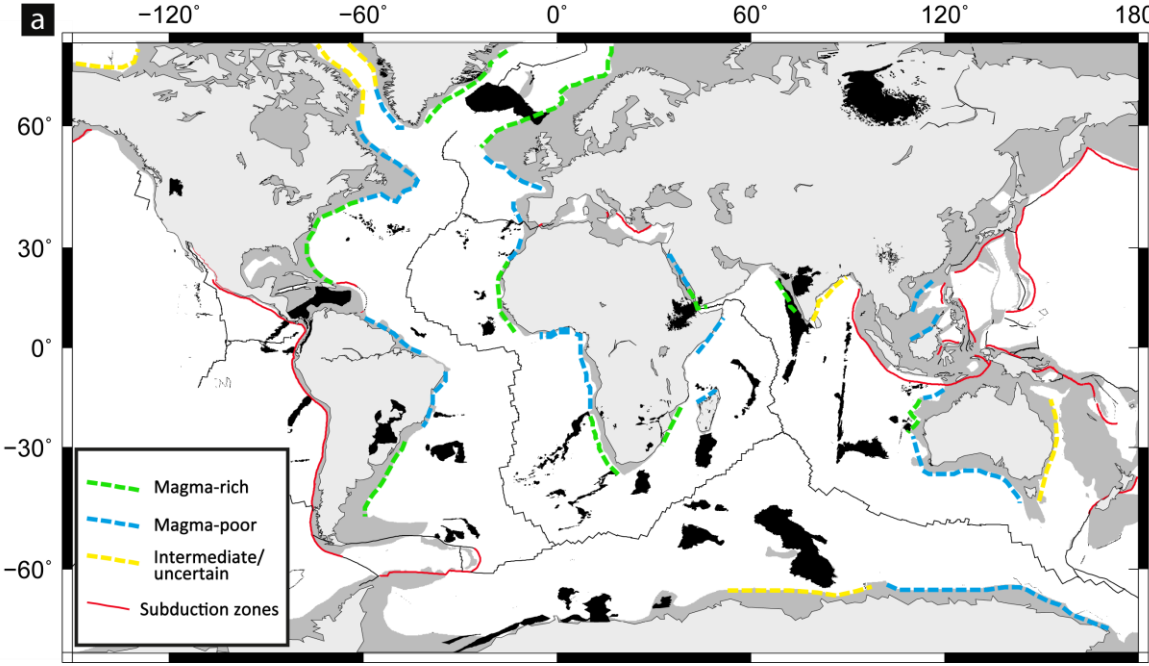
SI is extremely fast

Most initiation events are proximal to pre-existing subduction zones

90% of the worldwide trenches are located at less than 200 km from continental margins



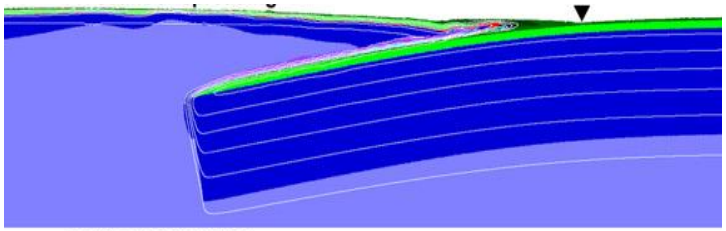
Lallemand & Arcay (2021)



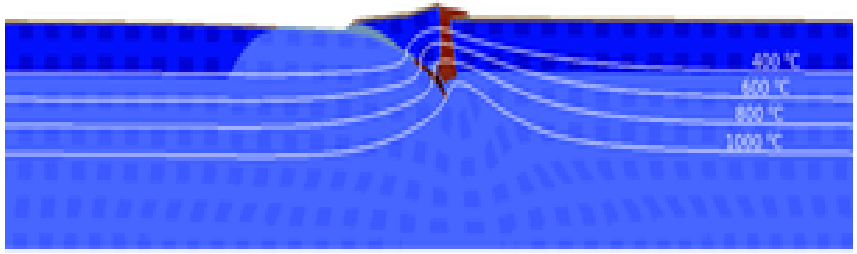
How does subduction initiate ?

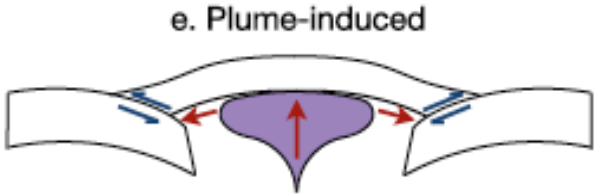
Intra-oceanic

Transform faults (e.g. Gerya, 2008)
Mariana trench ?



Mid-oceanic ridge or core complex (e.g. Maffione et al. 2015) Dinarides ? New Caledonia ?

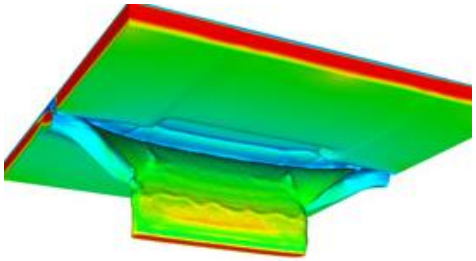




Plume induced (Gerya 2015; Burov and Cloetingh 2010)

...

Passive margin

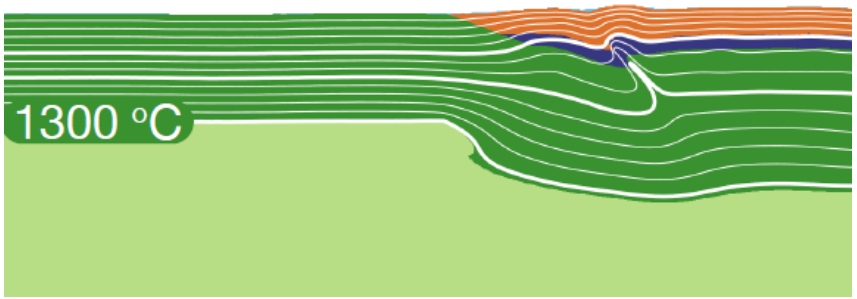


Lateral propagation–induced subduction initiation (e.g. Zhou et al. 2020; Duarte, 2013)

Caribbean ? Scotia Sea ?

Our study

Forced subduction initiation (e.g. Kiss et al. 2019)
Alps ?

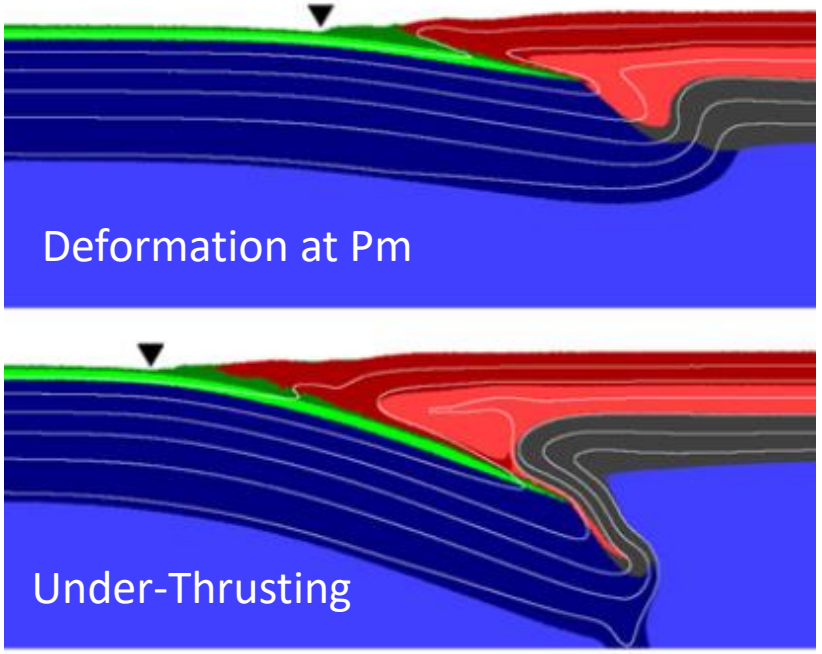


How subduction initiate ?

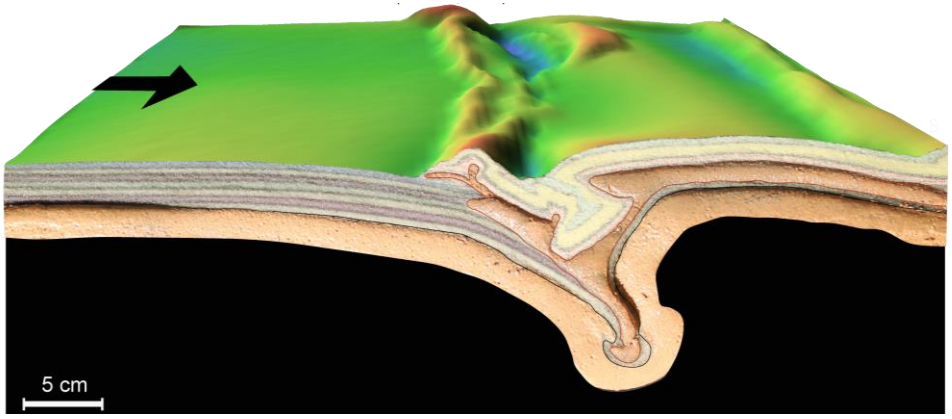
Yes but under restricted conditions …

Forced SI

- Deformation at PM controlled by the **ductile strength continental crust**.
- Underthrusting regime is governed by the **strength of the subcontinental lithospheric mantle**



Nikolaeva et al., 2010



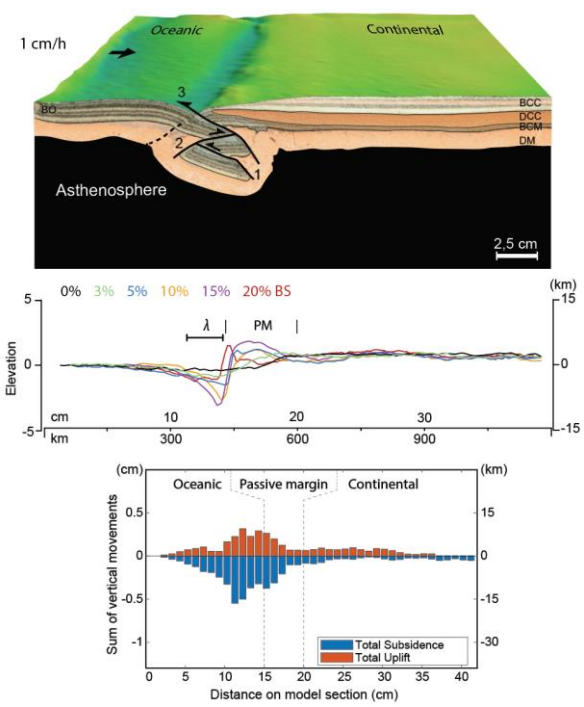
Auzemery et al., 2021. *Tectonophysics*, *817*, 229042.

Analogue model of SI

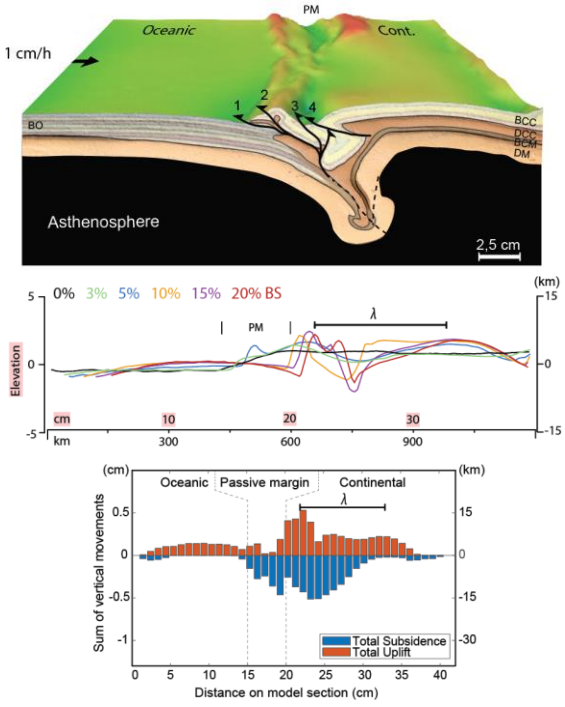
Auzemery et al. (2021). Passive margin inversion controlled by stability of the mantle lithosphere. *Tectonophysics*.

Weak — **Intermediate** — **Strong** → **Ductile strength (viscosity ductile)**

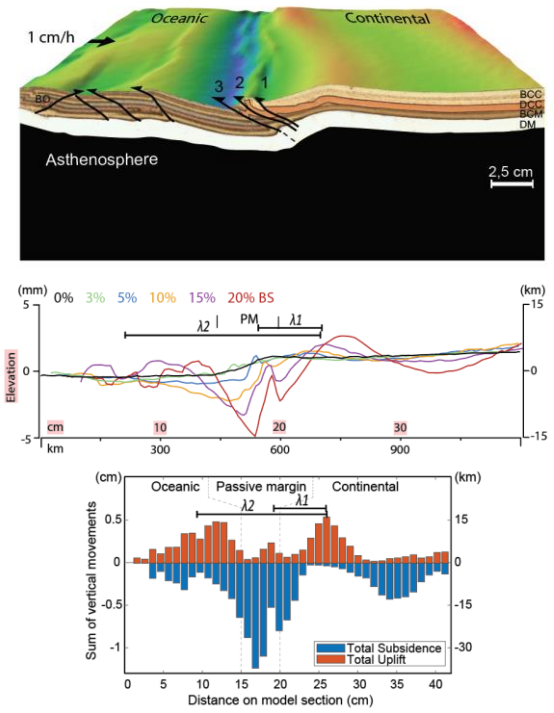
Intra-oceanic subduction → **Subduction at Passive Margin** → **Lithosphere folding**



Localized deformations intra-oceanic



Localized deformations at PM



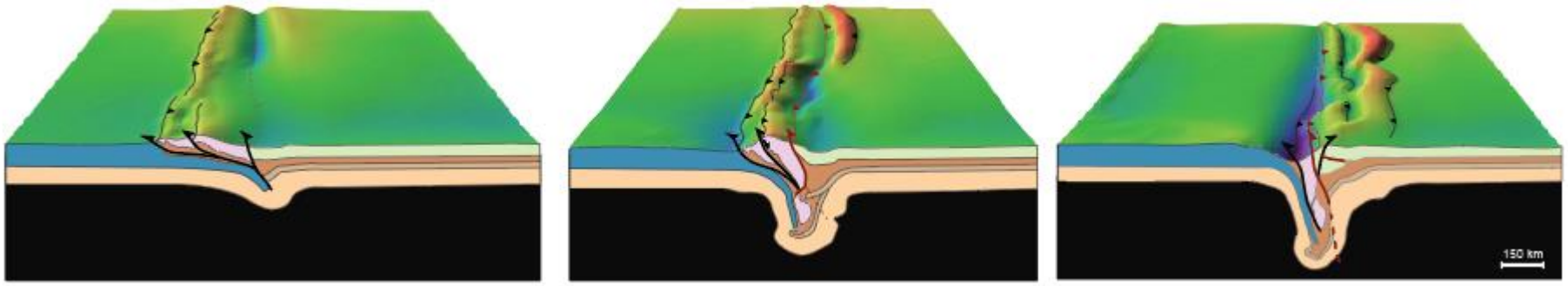
Distributed deformations

Distribution of deformations with time

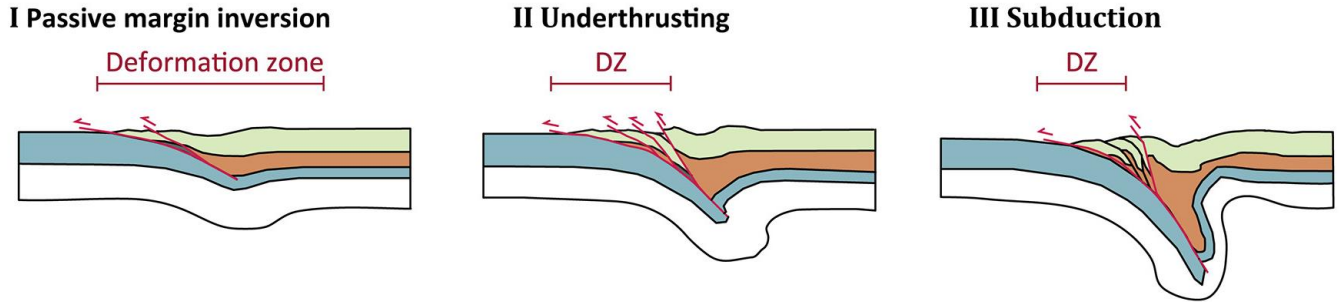
Distributed deformations

Localized deformations

Time



Subduction initiation at passive margins



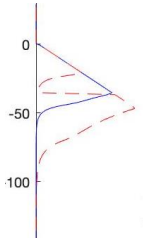
Role of Thermal age for SI

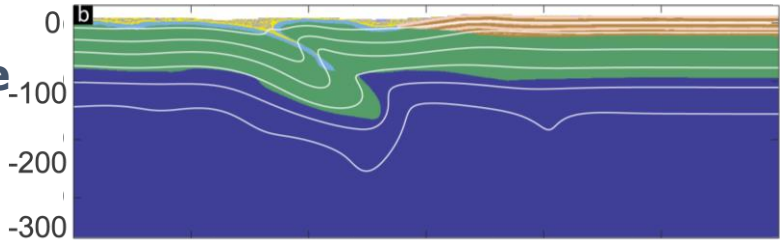
v= 1 cm/y

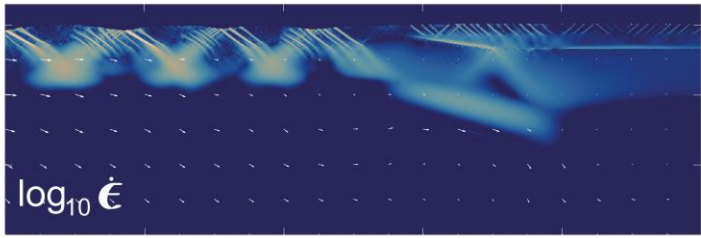
t= 25Myr

Young lithosphere

~ 30 Myrs



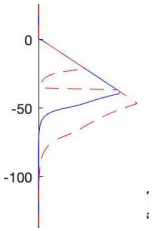


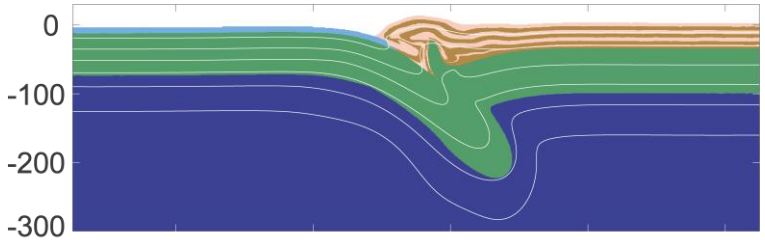


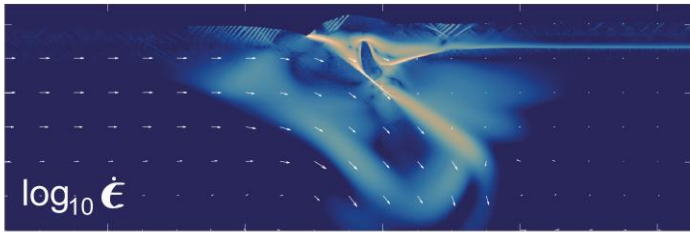
Intra-oceanic

Intermediate age

~ 70 Myrs



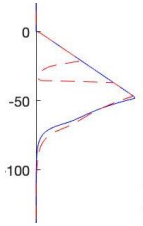


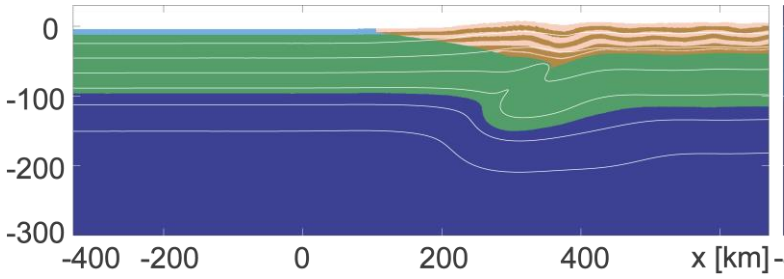


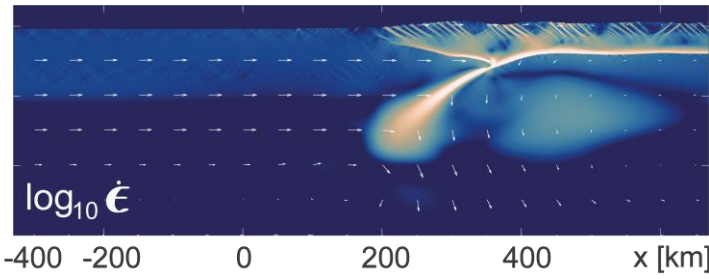
Subduction at passive margin

Old lithosphere

~ 110 Myrs







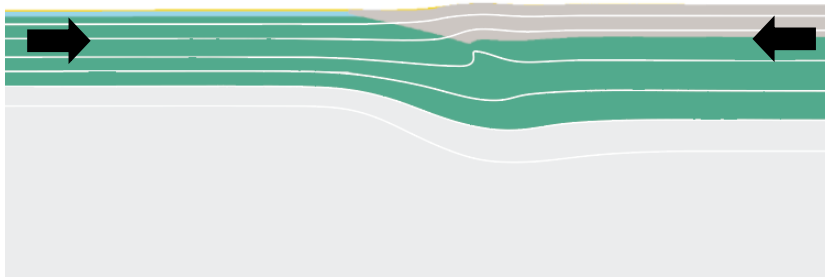
Continental folding/ partial delamination

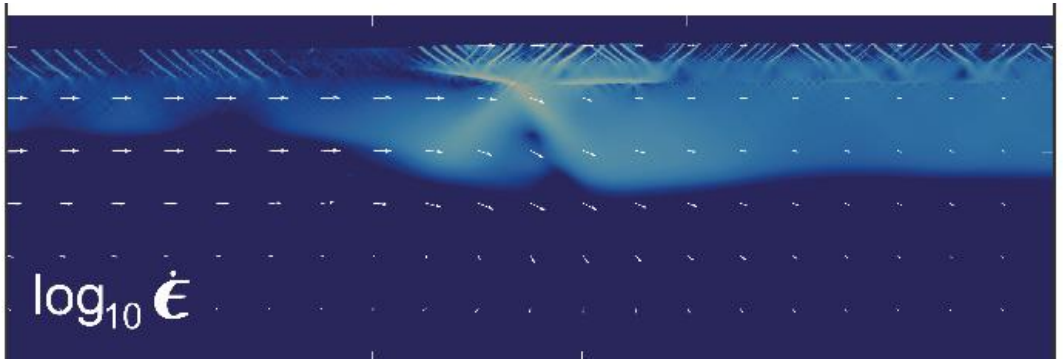
SI at Pm

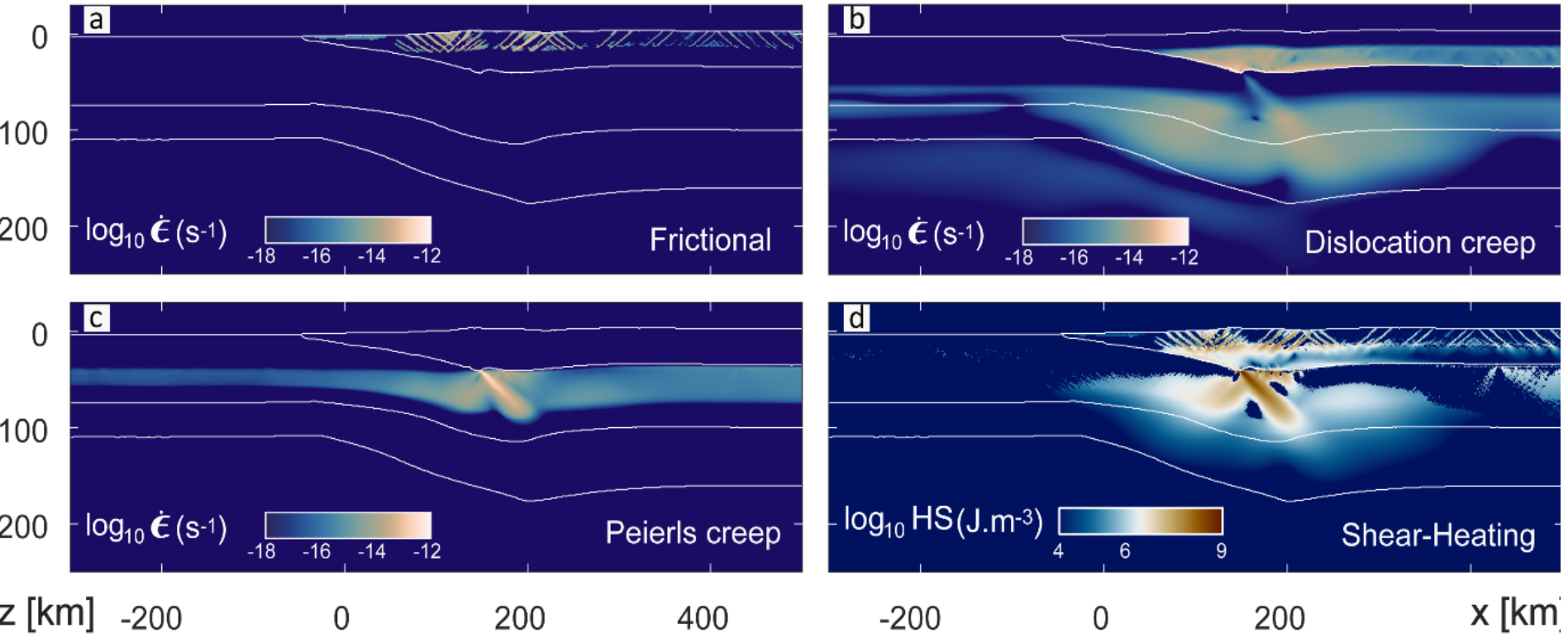
v= 1 cm/y *t*= 25Myr

Auzemery et al., 2020. GPC

also in Kiss et al., 2019

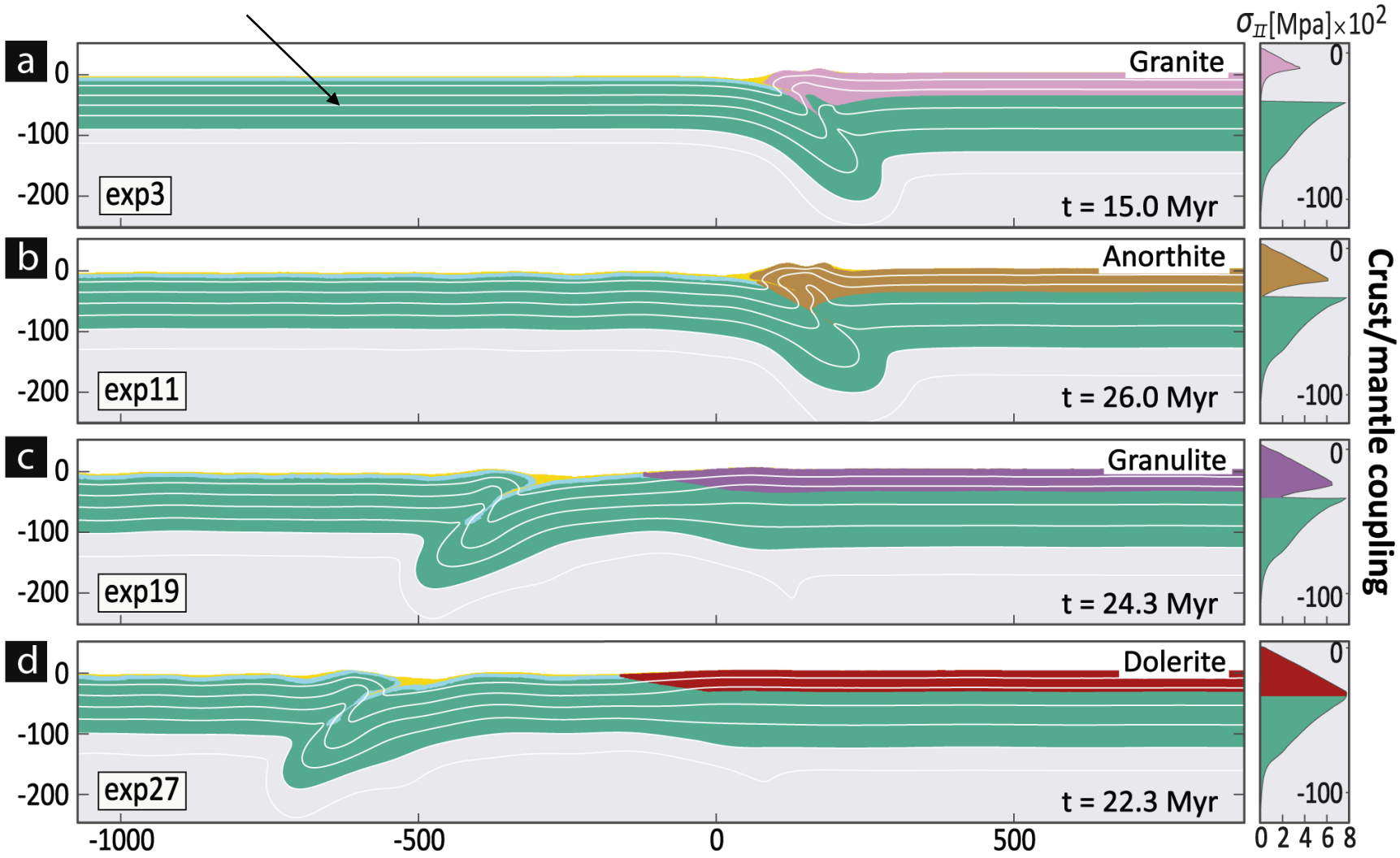






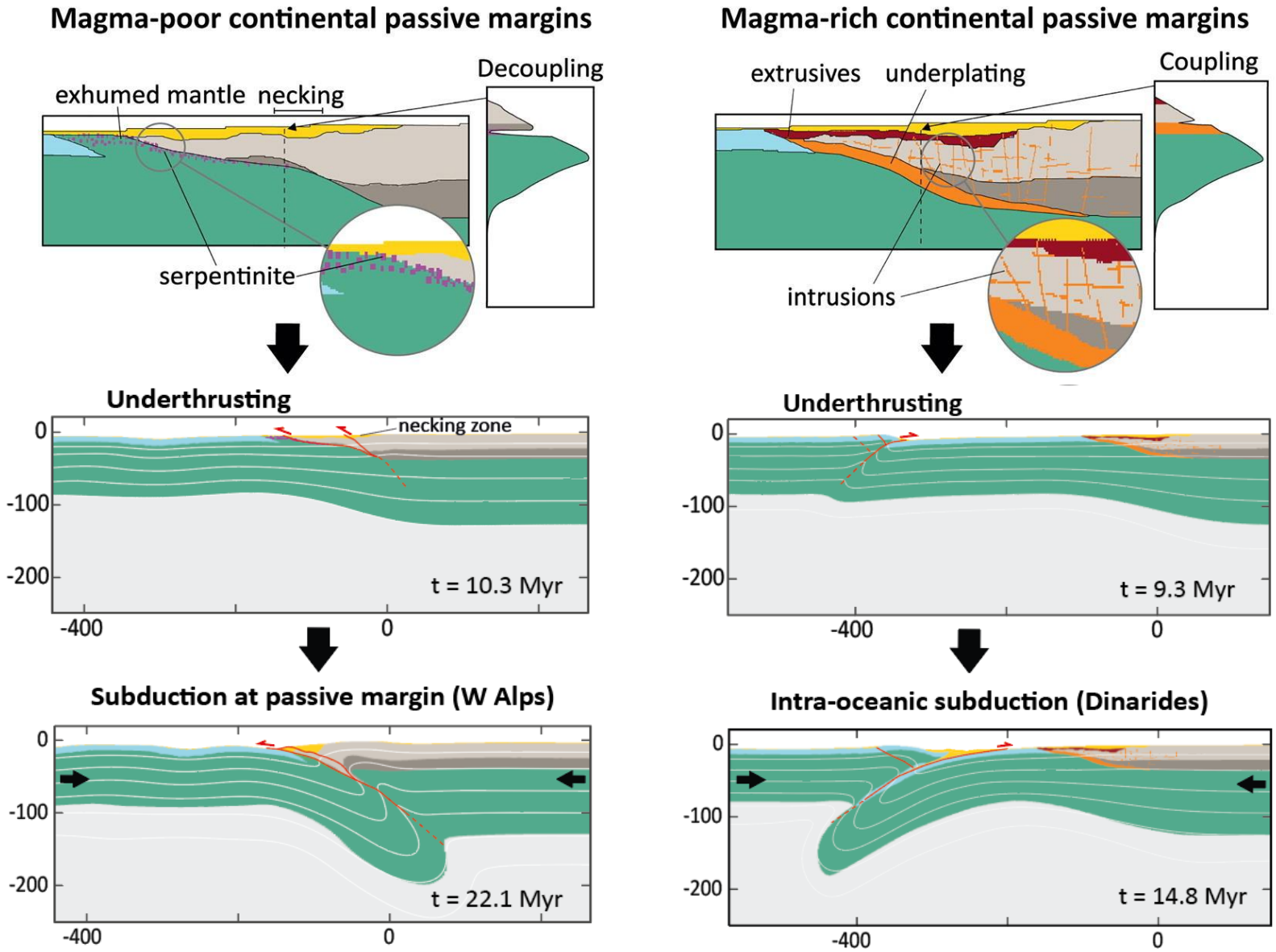
2) Crust-mantle Coupling/decoupling at PM

70 Myr O. lithosphere



Auzemery et al., 2022. Influence of magma-poor versus magma-rich passive margins on subduction initiation. Gondwana research

Application to magma-poor versus magma-rich passive margins (Auzemery et al., 2022. Gondwana research)



Natural examples

A-B Western Alps

60-70 Myr

magma-poor margin

SI at Passive margin

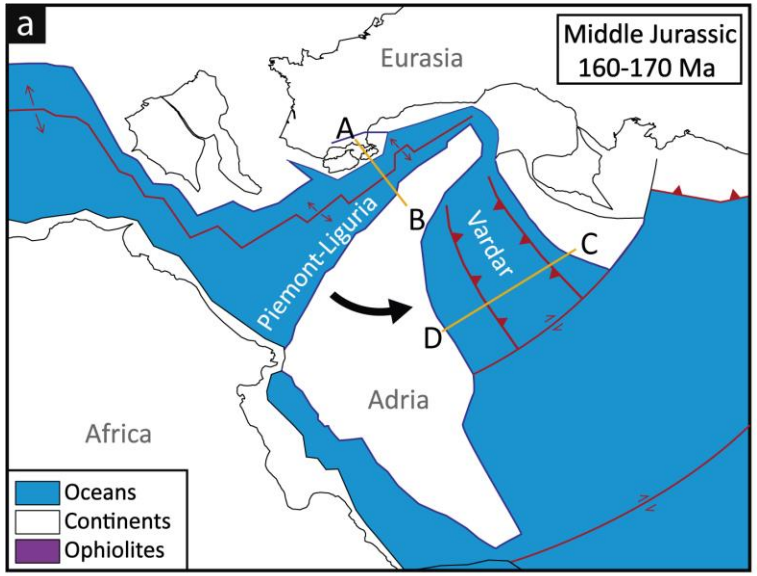
C-D Dinarides

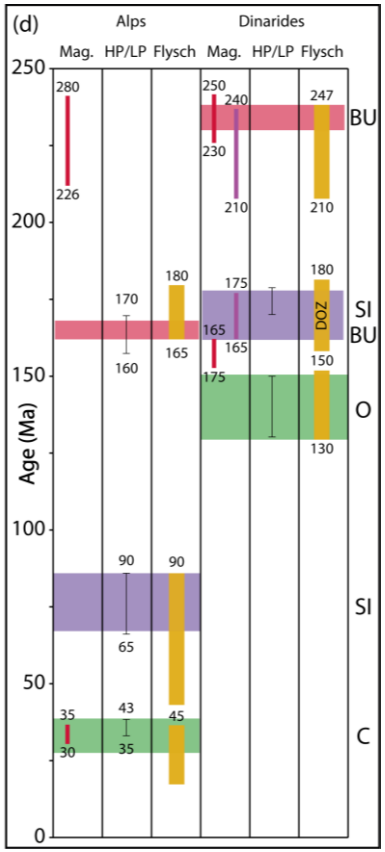
60-70 Myr

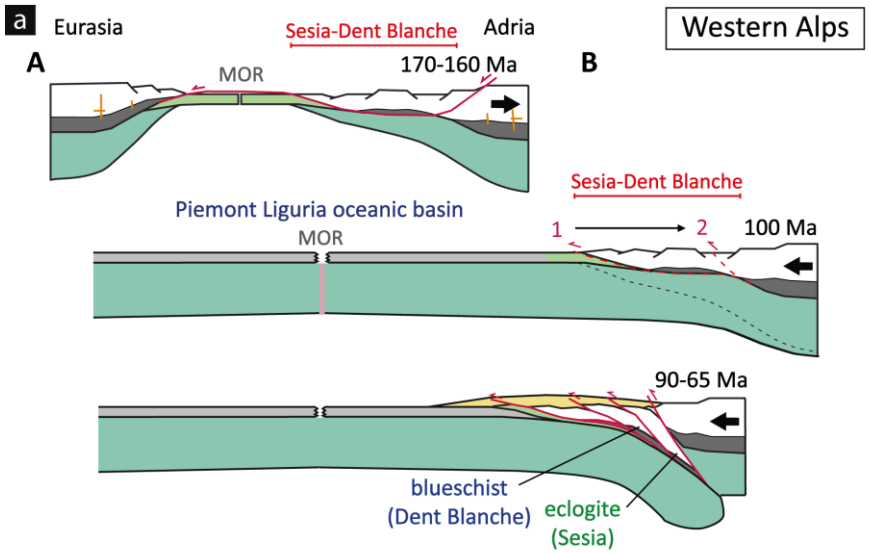
Magma-rich margin

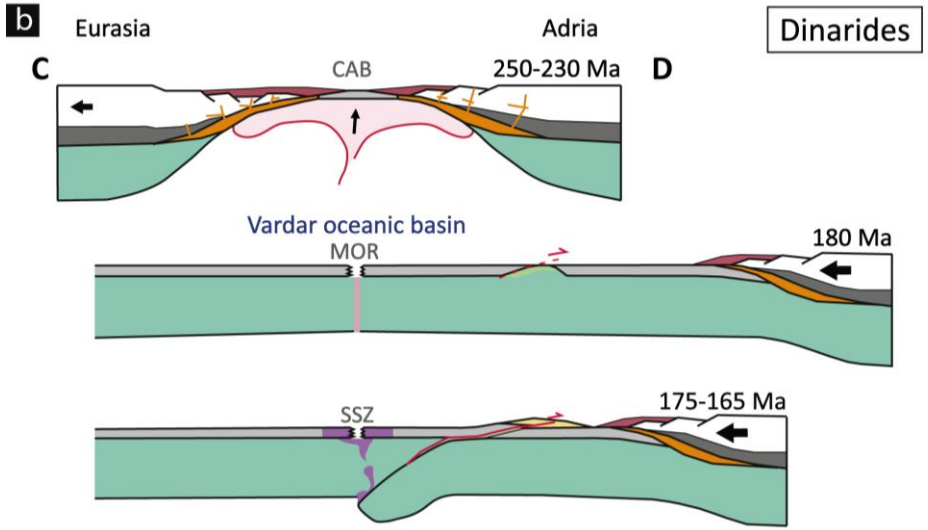
Intra-oceanic SI

and obduction



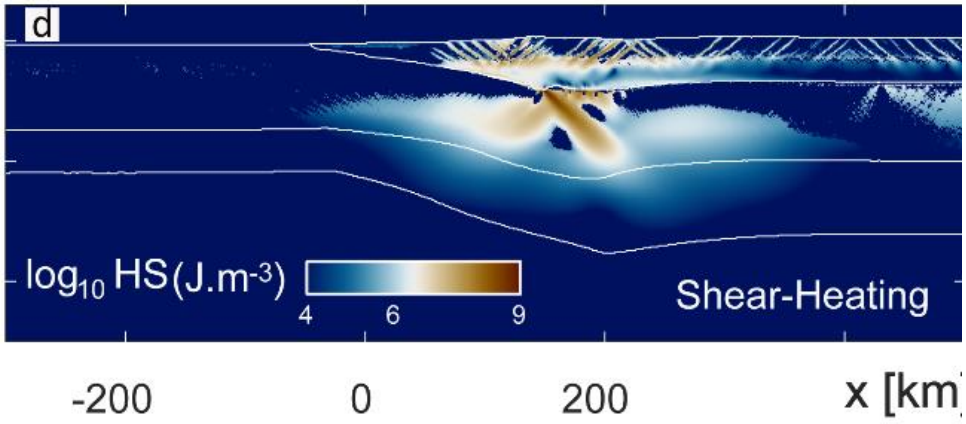






Subduction initiation may be possible at passive margin under restricted condition:

- **Spontaneous** SI at passive margins is **unlikely**
- SI is also feasible for shortening of **young oceanic basins**.
- Successful SI furthermore requires:
  - **Crust/mantle decoupling** allowing for deformation of the ductile lower crust.
  - Efficient weakening mechanisms enabling failure of the lithospheric mantle.
- Promising sites for SI:
  - **Magma poor hyper-extended passive margins** exhumed and serpentinized mantle lithosphere, which facilitates strain localization and the formation of a proto-plate boundary.
  - Thermally weakened passive margin lithospheres, by mantle plume or baby plumes.



Auzemery et al., 2020. Global and Planetary change

Thank you

for

your attention

SUBITOP

And by the way …

I am looking for a job…

Thank you

for

your attention

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