Slab Tearing Caused by Trench's Dramatic Retreat and Bending

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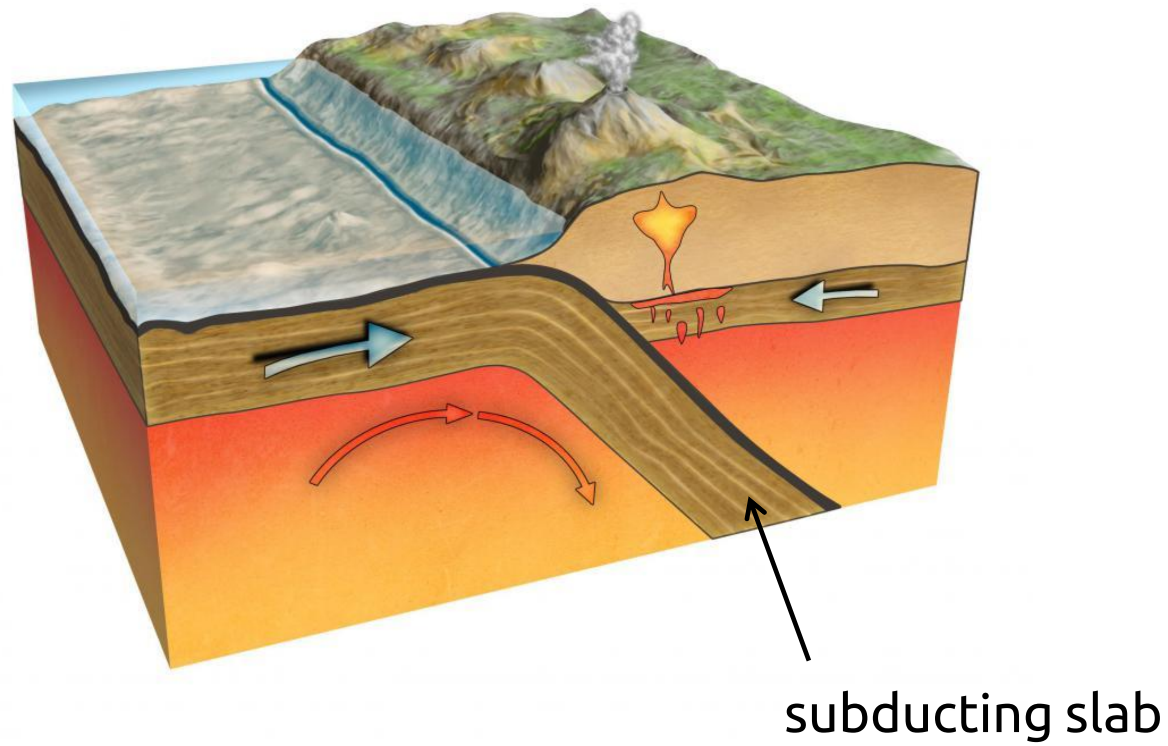
Subduction

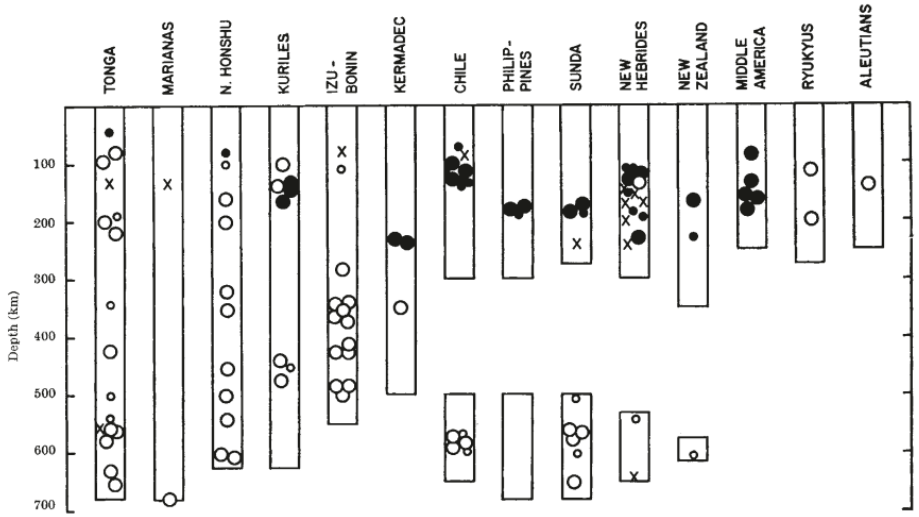
- Subduction process is one of the most important processes on Earth.
- Researches on slab morphology provide information about slab's property, mantle structure and flow field, tectonic history, etc.



(m.wisegeek.com)

Slab tearing

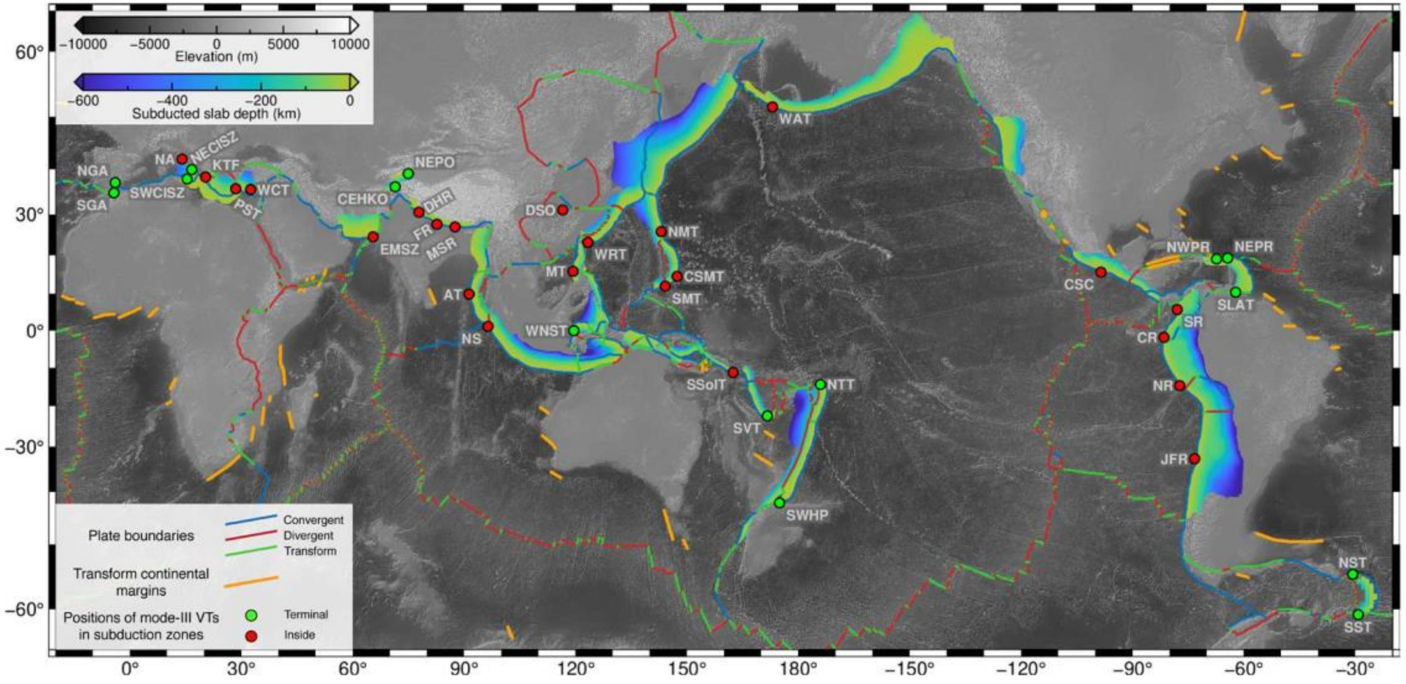
- Proposed to explain seismic gaps inside subducting slabs



(Isacks and Molnar, 1969)

- More and more observations of slab tearing

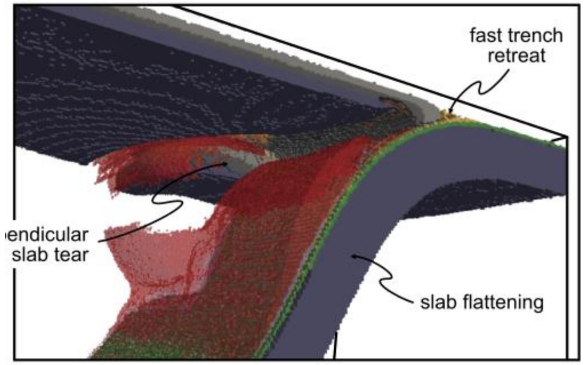
below shows global distribution of vertical tearing (VT)



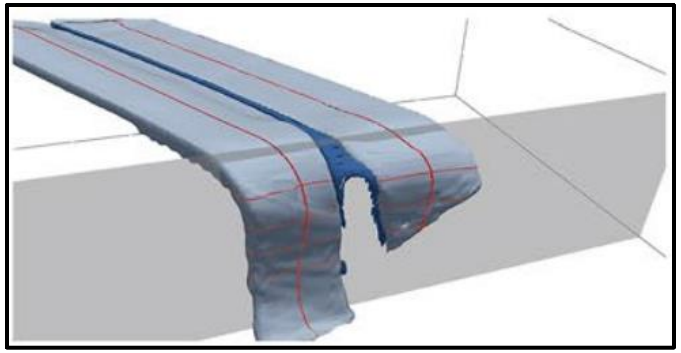
(Chen et al., preprint)

Mechanisms of slab tearing

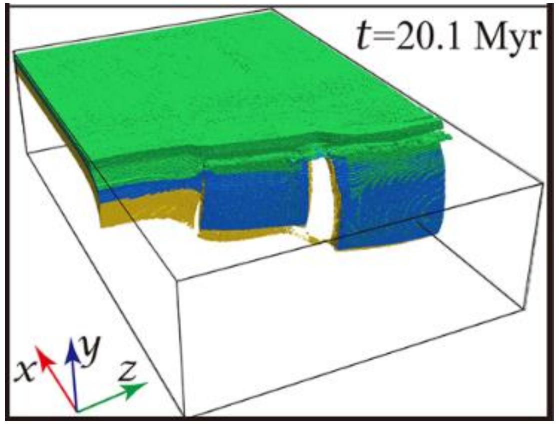
- Co-subduction of buoyant blocks
- Mid ocean ridges or transform faults
- Pre-existing fracture zones
- ……



(Menant et al., 2016)



(Xin et al., 2023)



(Cui et al., 2022)

Mechanisms of slab tearing

- Co-subduction of buoyant blocks
- Mid ocean ridges or transform faults
- Pre-existing fracture zones
- ……

-> There always exist lateral variations

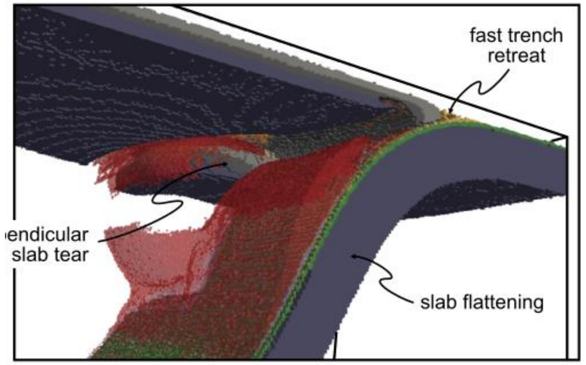
(eg: micro-continent, weak zones)

-> Can a homogeneous plate tear?

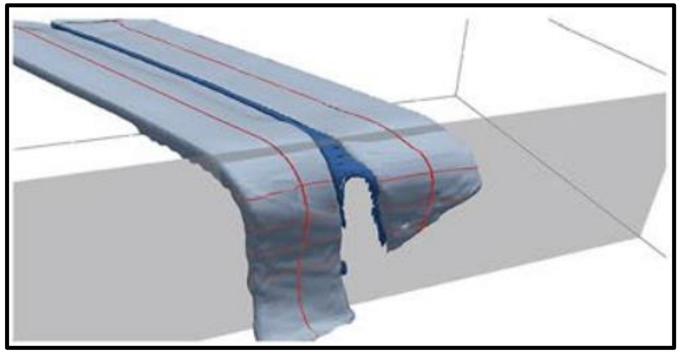
-> Here we discuss a new scenario:

slab tearing caused by

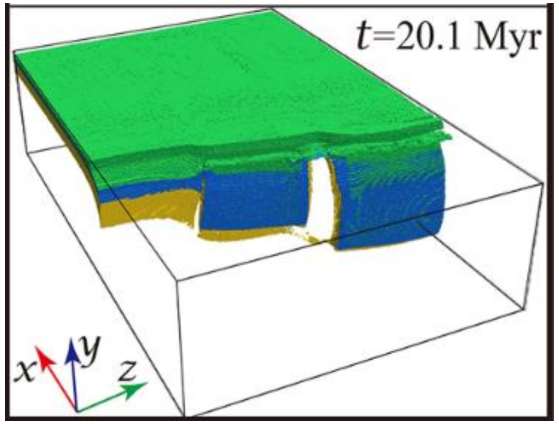
highly-bended trenches



(Menant et al., 2016)



(Xin et al., 2023)

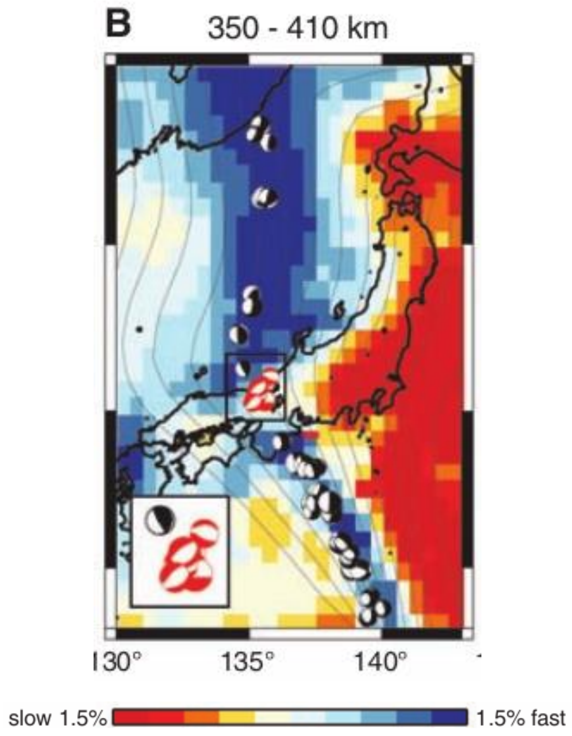


(Cui et al., 2022)

How a bended trench causes slab tearing?

- An inspiring work:

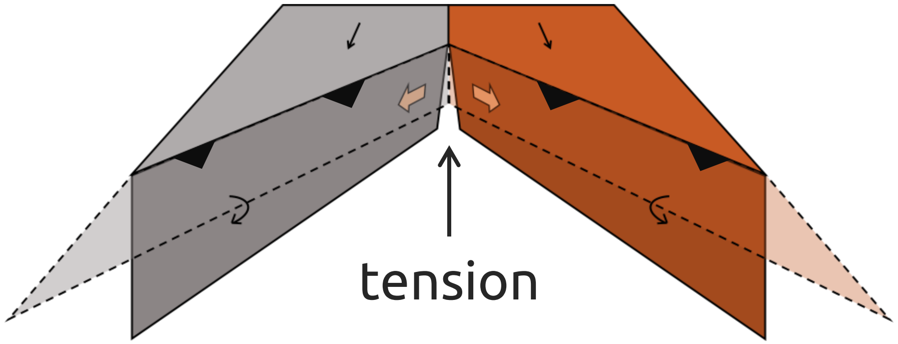
slabs torn apart when they bend to flatten over the 660km discontinuity (at Japan)



(Obayashi et al., 2009)

- Similarly:

slab's tension and tearing at a concave trench



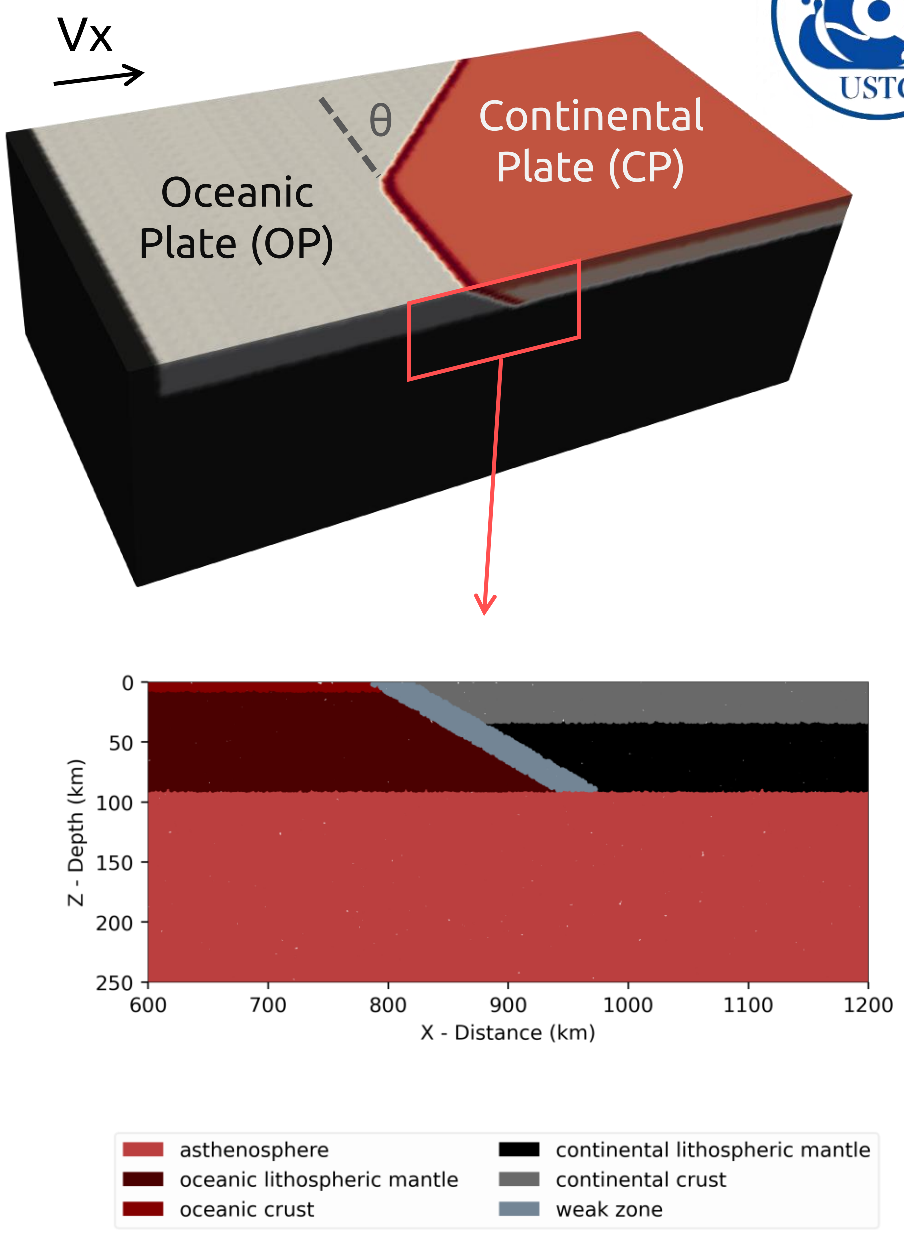
Methods

- Numerical Simulations:

  CitcomCU (modified version)

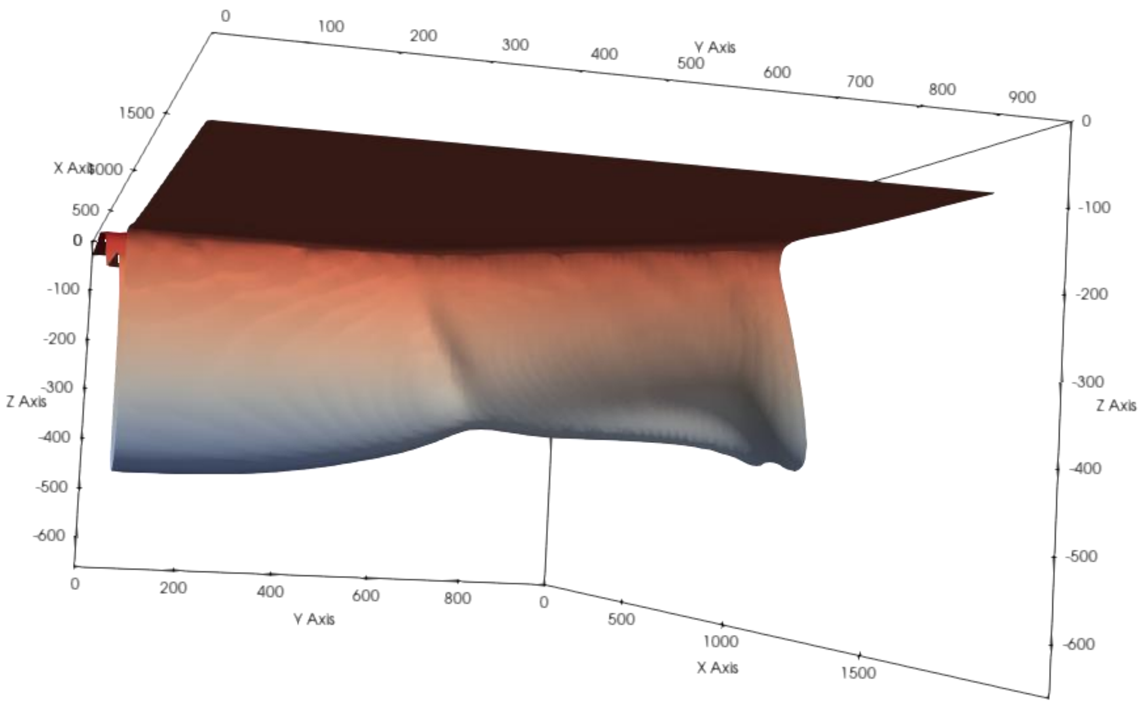
- Reference Model:

Bound. Cond.	Free-slip
Box	1980×990×660 km^3
Resolution	10.3×10.3×10.3 km^3
OP's Age	70 Myr
OP's Velocity	6 cm/yr；
Bending Angle θ	45°



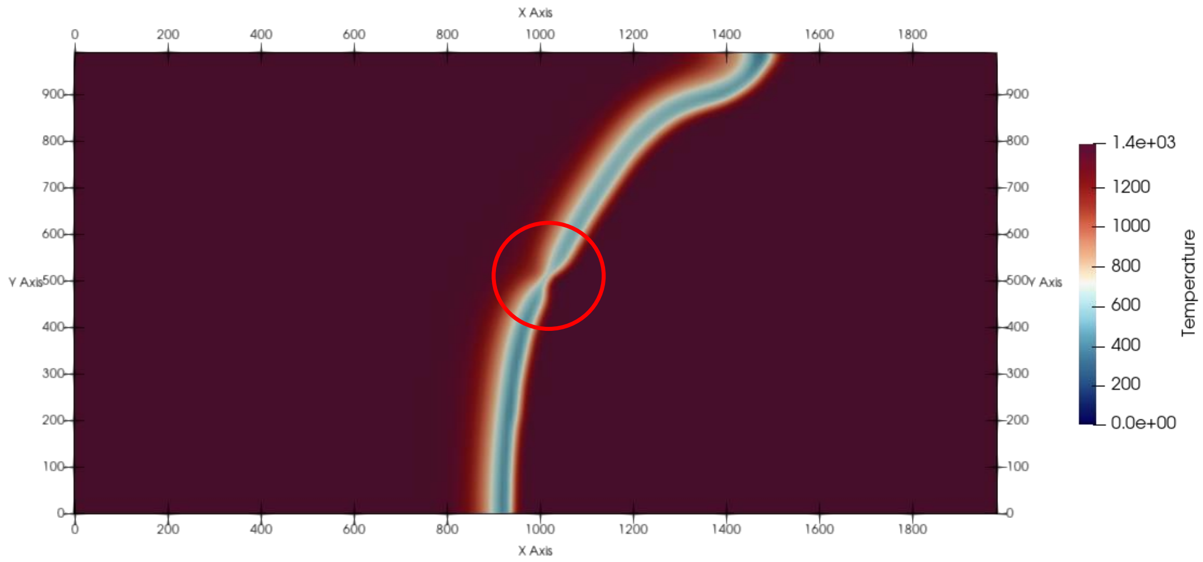
Reference model results (6.21Myr)

Slab morphology (1200℃ contour)



concavity inside the slab

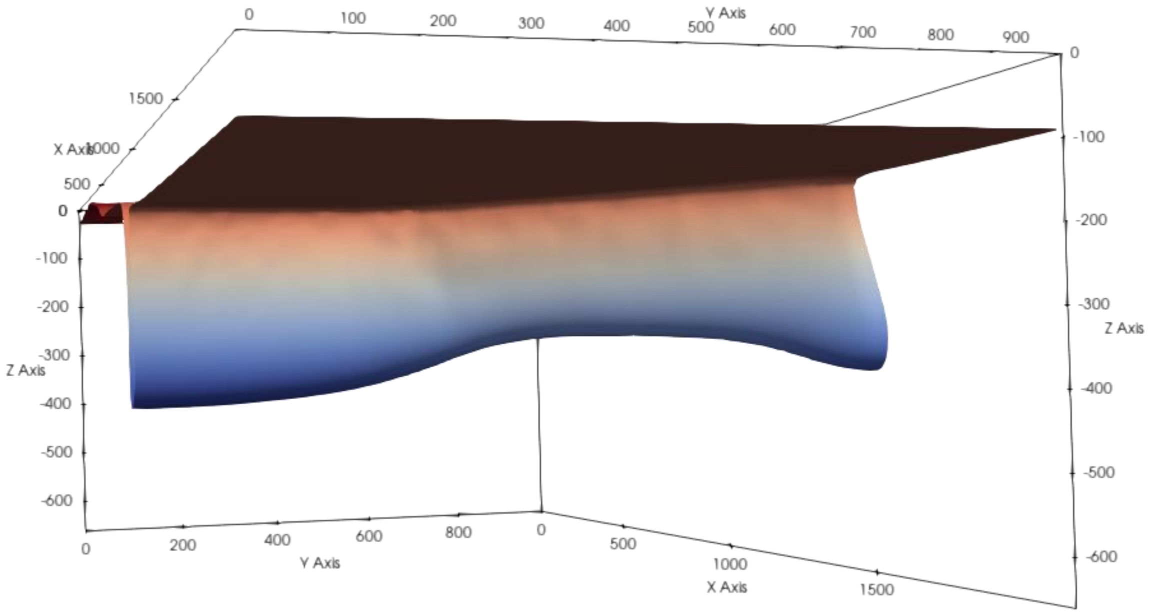
Temperature profile at 250 km depth



thinning of the subducting slab

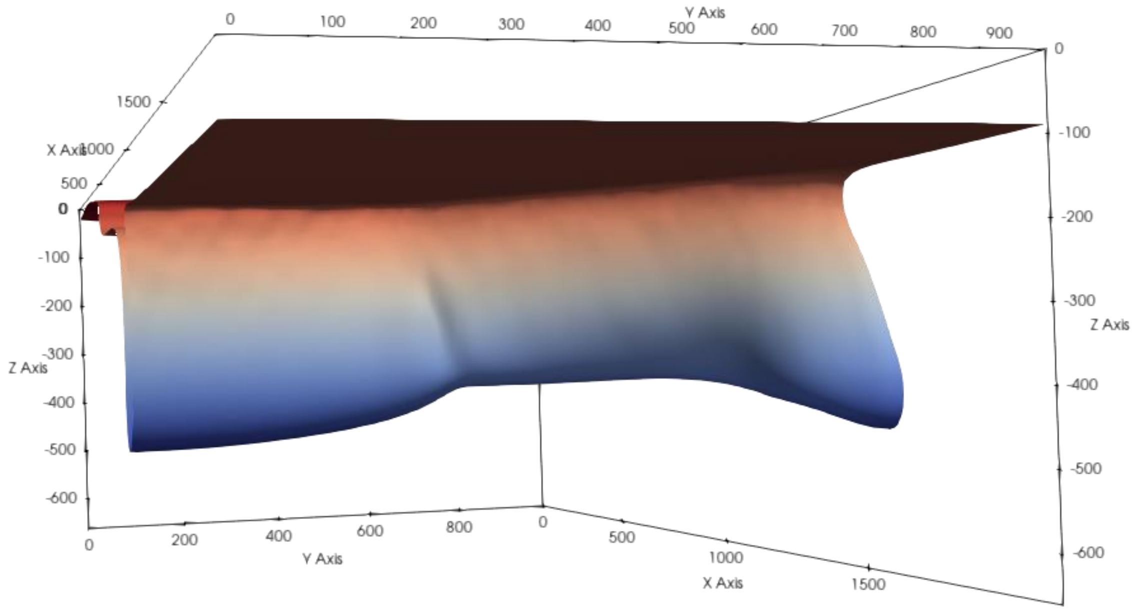
Influence of OP's age & velocity

Younger plate (20Myr)



slab more smooth, might due to lower negative buoyancy and less tension

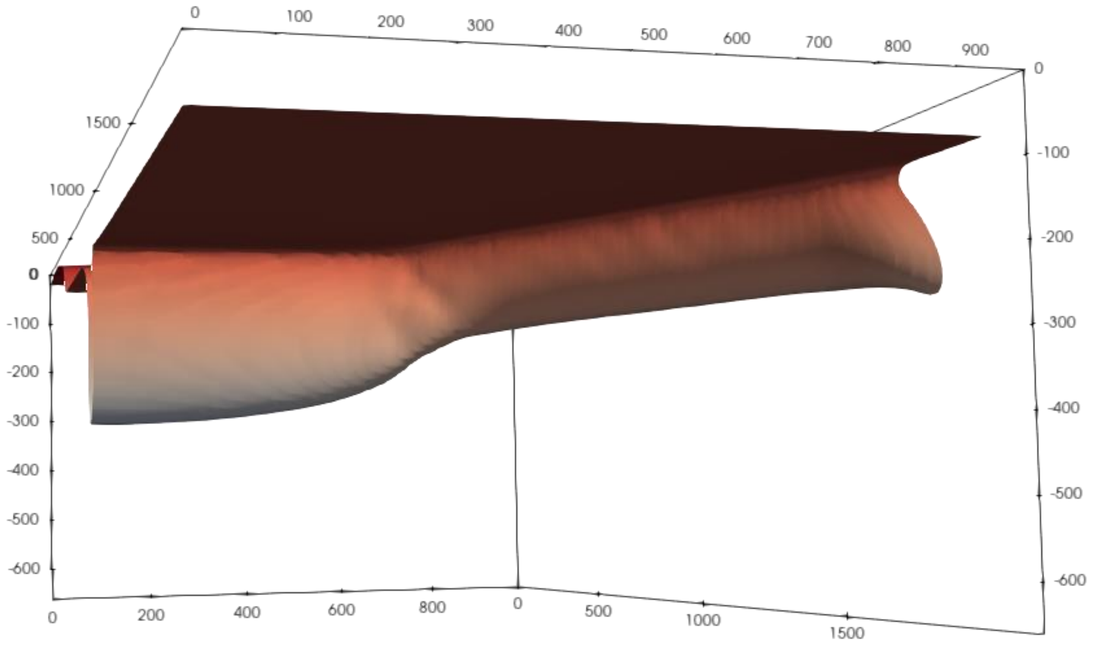
Faster plate (10cm/yr)



show no apparent difference

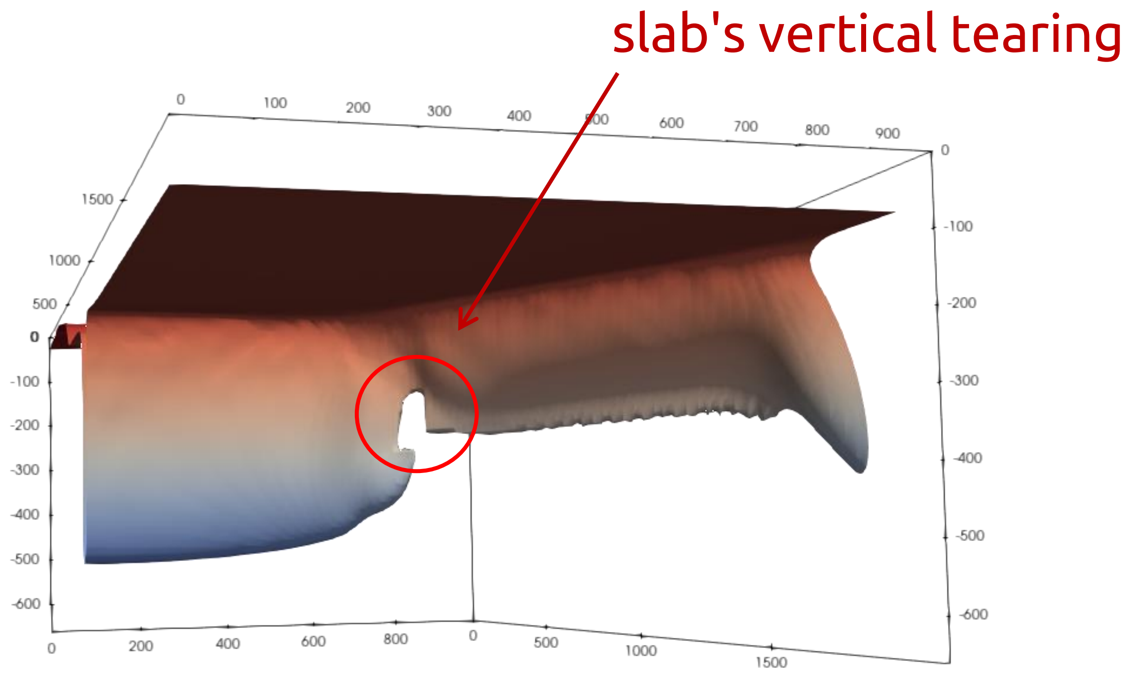
Influence of bending angle: θ = 60°

4.83 Myr



no tear

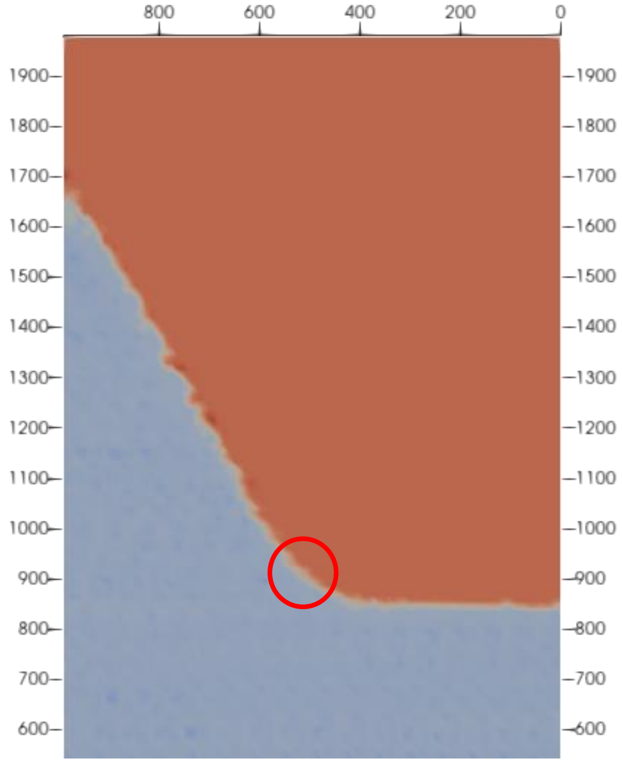
6.90 Myr



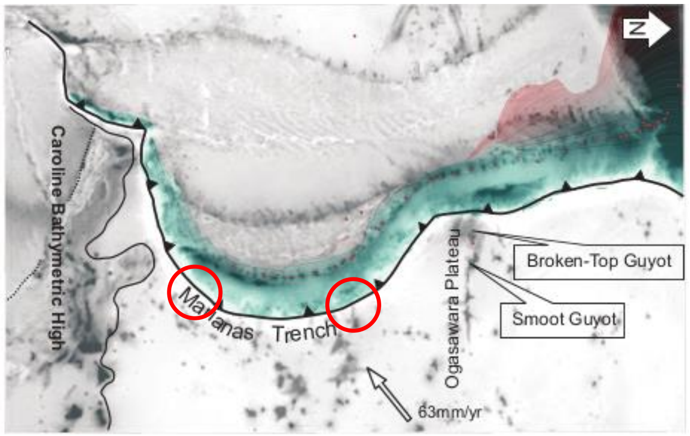
tear

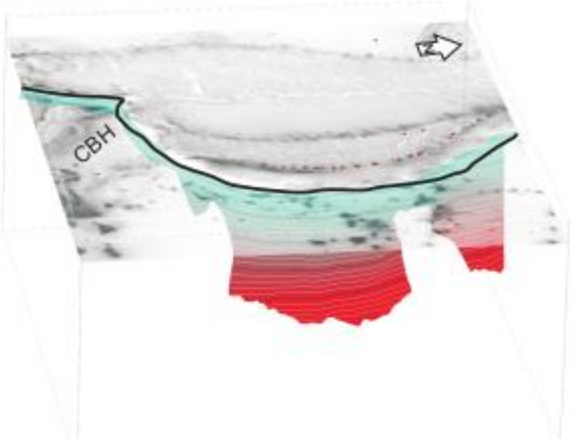
Discussion: Tearing at highly-bended trenches

Modeled trench geometry and the tearing position

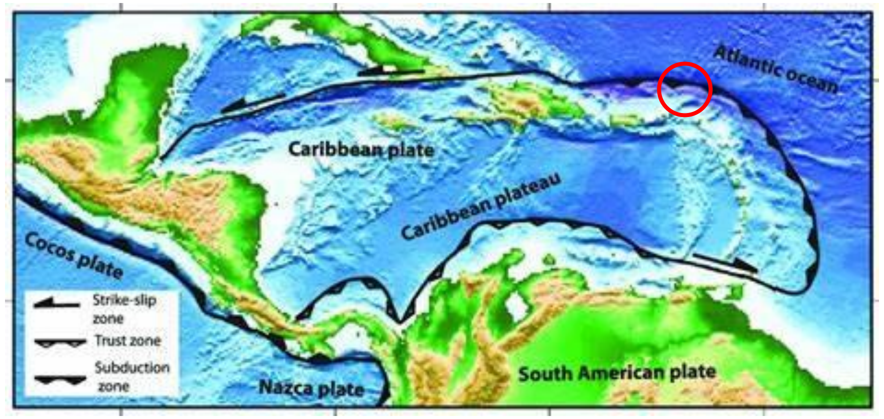


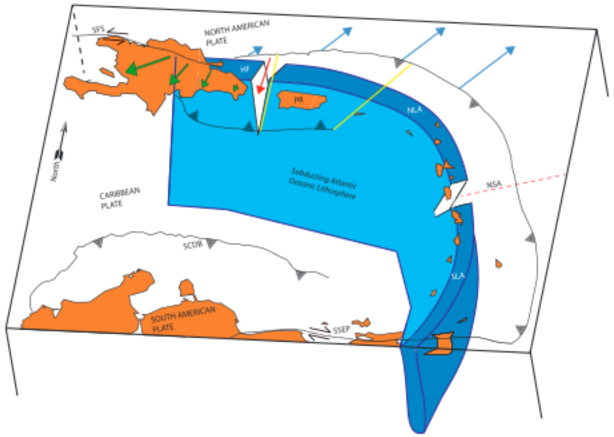
Mariana





North Caribbean

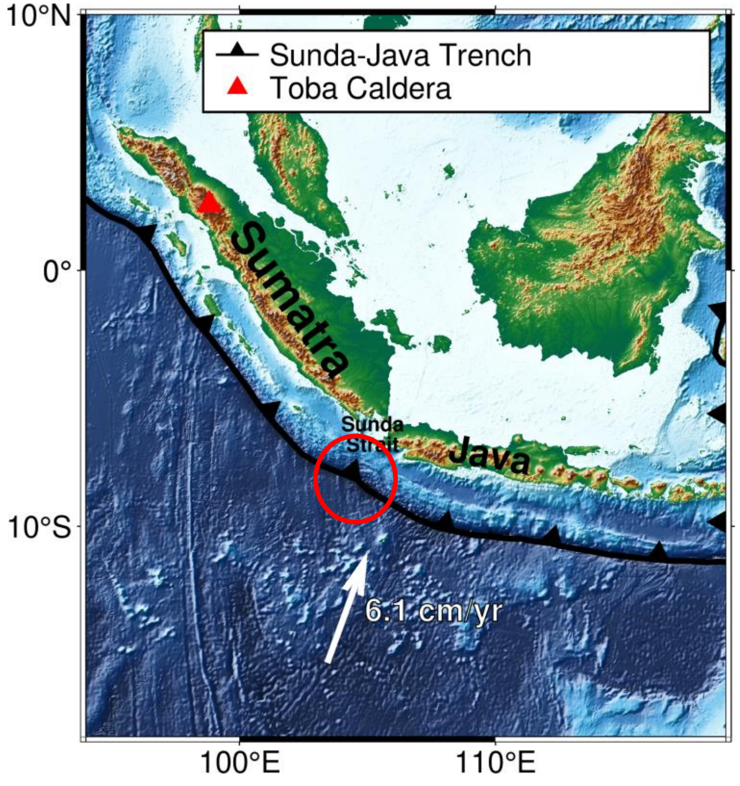


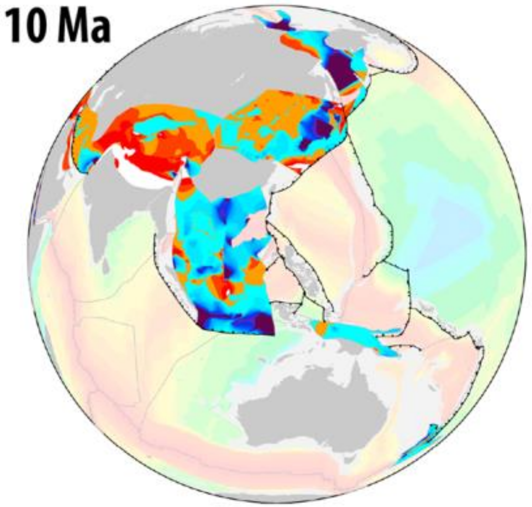


(Richards et al., 2012; Harris et al., 2018)

Discussion: Tearing at the Sunda Strait?

- Proposed by Liu et al. (2021), who suggested trench migration and the variation in the plate convergence angle may cause the tear

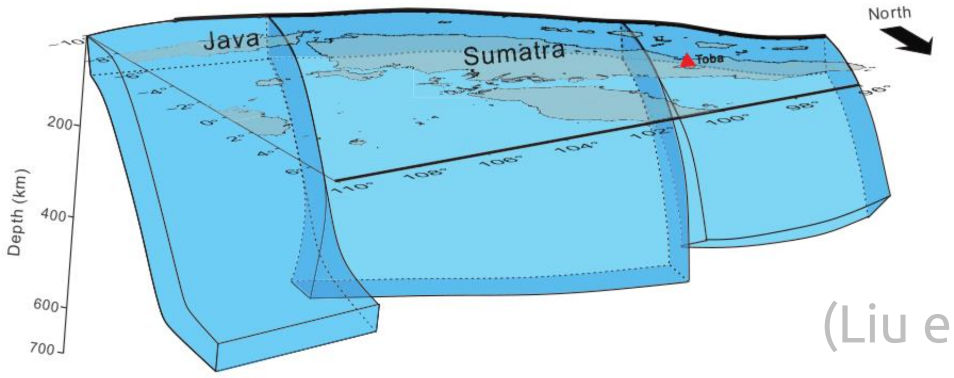




Reconstruction, showing trench's dramatic bending at the Sunda Strait

(Muller et al., 2019)

Sketch of the slab, based on seismic tomography



(Liu et al., 2021)

Conclusions

- A strongly bended trench could cause tension and even vertical tearing of the slab, which can be observed at Mariana and North Caribbean.
- In a more realistic scenario, this effect might be weakened, influencing slab morphology together with other factors.
- Main controlling factor in this tearing process is trench's bending angle; oceanic plate's age and velocity plays a secondary role.
- At the Sunda Strait, this effect combined with dynamic history of trench retreat may contribute to the proposed slab tear.

- The model still needs improvements in setup, resolution and parameter tests, and comprehensive discussion with relevant researches.

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Thanks for Listening!