Slab tearing beneath Sumatra:
Insights from 3D numerical modeling

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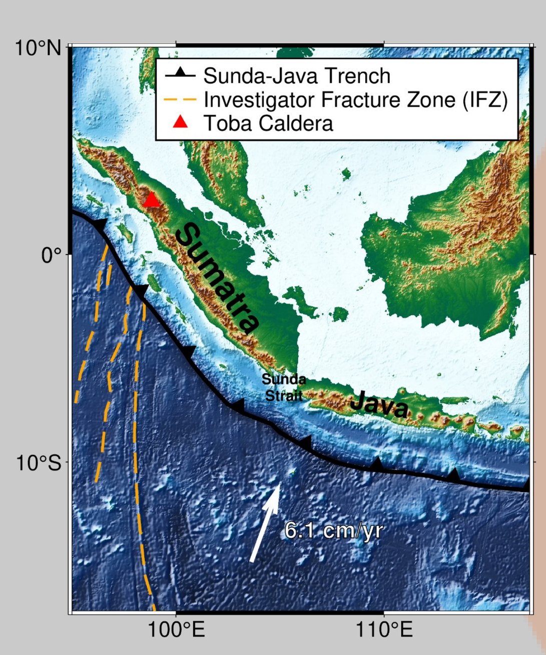
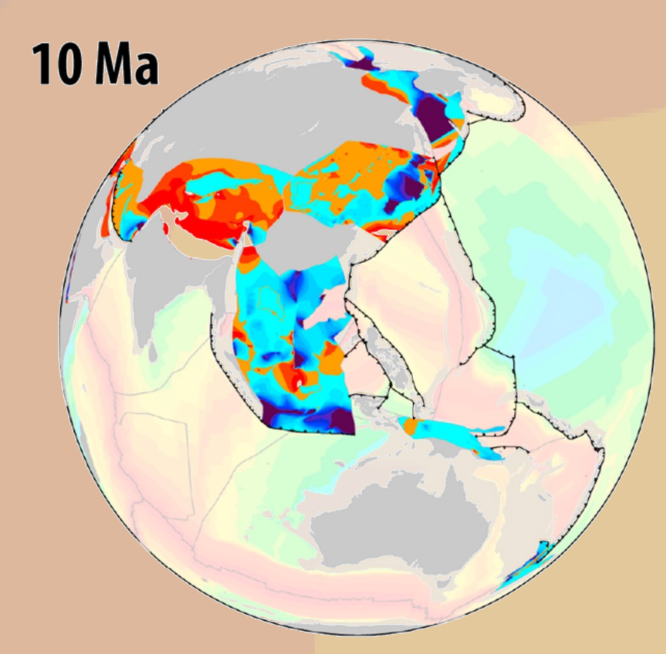
Introduction

Slab tearing (ST) is a geodynamic process commonly observed in worldwide subduction zones, referring to subducted plate's breaking off horizontally or vertically. Recently, two subvertical slab tears in Sumatra have been revealed by high-resolution P-wave tomographic imaging derived from seismic traveltime data (Liu et al., 2021). The western one is beneath the Toba caldera, and the other is beneath the Sunda Strait.

In numerical simulations, the formation of ST is usually attributed to collision between a buoyant continental block and the subduction zone, which is, however, not the case here in Sumatra. To this end, we have performed large-scaled 3D numerical simulations to study the scenario of Sumatran strongly-bended-trench subduction. Based on the preliminary results, we find that the Investigator Fracture Zone (IFZ) might be responsible for the western tear, and the lateral convergence angle variation could generate extensional stress large enough to tear the slab at east.

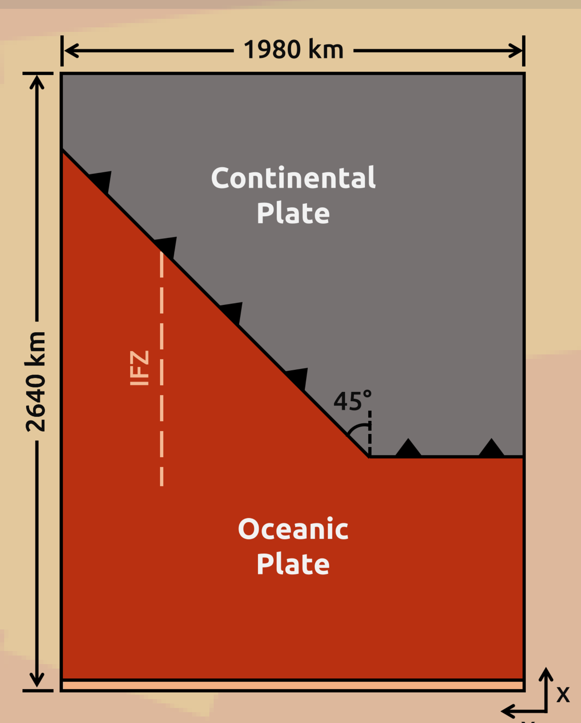


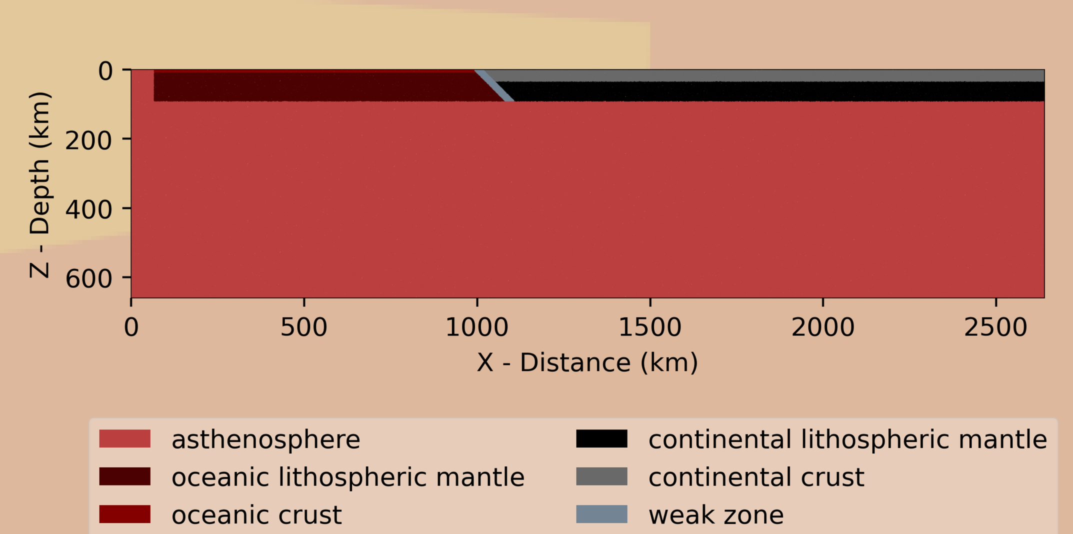


Methods

The 3D geodynamic simulation were conducted using a modified version of CitcomCU, which solves the conservation equations of mass, momentum and energy (Leng and Gurnis, 2015).

The size of the model region is $2640 \times 1980 \times 660$ km^3, with a southern oceanic plate (OP) pushed by a constant horizontal velocity and a northern continental plate (CP). The shape of the trench is set according to reconstructed plate boundaries at ~10 Ma (Müller et al., 2019). All boundary conditions are set to be free-slip. The initial temperature profile of OP are defined by half space cooling model, and temperature increases linearly within CP.

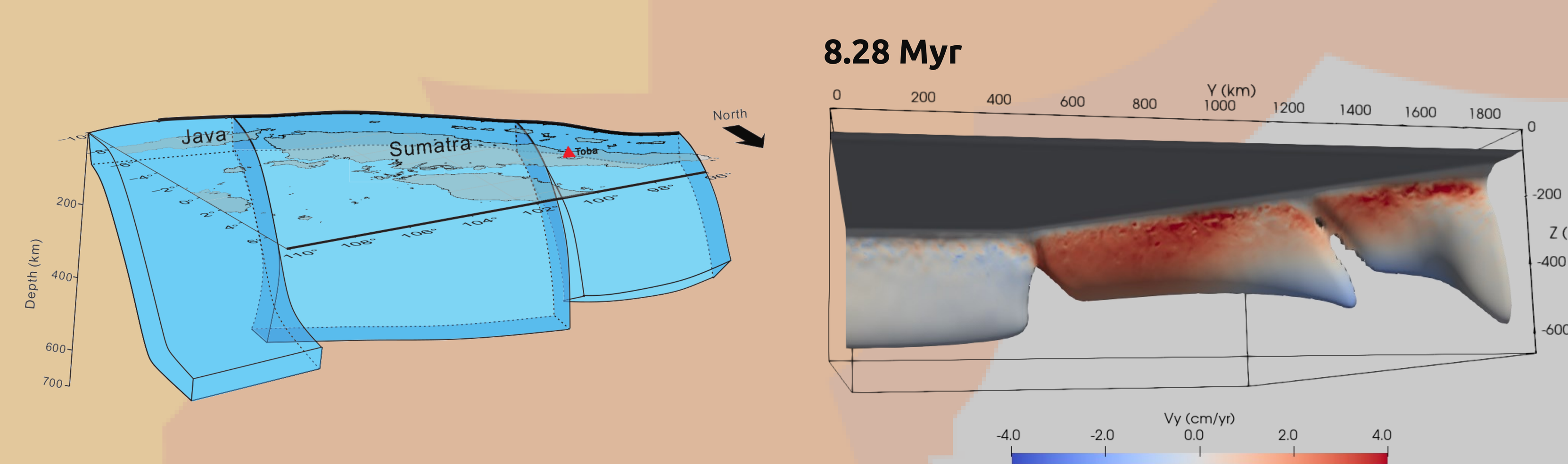




Results

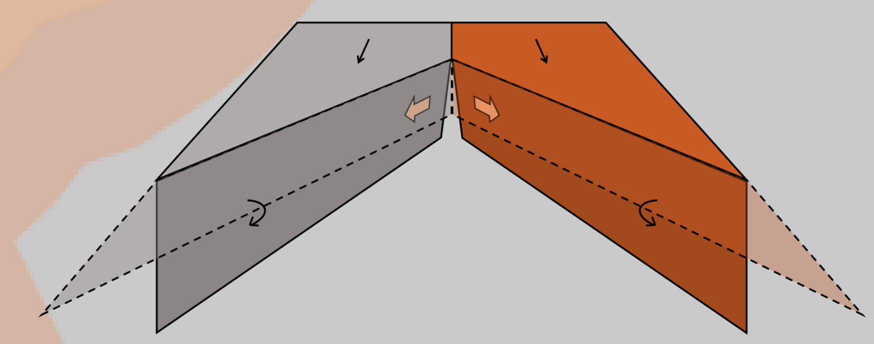
Below shows model evolution at 5.52 Myr and 8.28 Myr, in which the eastern tear initiates and has propagated through the whole slab. The slab morphology is represented by the 900 ℃ iso-temperature contour, with color indicating y-axis velocity V_y.

Before ~6 Myr, we can see from the reddish color of the western slab (with larger Y coordinate value, referring to the Sumatran part) that it sinks southwestward , different from the southward-sinking Java slab. This direction contrast generates extensional stress large enough to tear the slab apart at the Sunda Strait. As for the western tear, it appears naturally at ~8 Myr due to the existence of IFZ.



Discussion

We have used 3D numerical model to explore how ST can develop at fracture zones and at the “trench corner”. As shown, when a plate is subducted at a concave trench, different parts of it bend towards different directions, causing tension inside the slab that potentially leads to ST (figure inspired from Obayashi et al., 2009).



Nevertheless, as a preliminary attempt, there exist lots of limitations in our work:
1. Model simplification, including shape of the trench, the fracture zone setup, etc.
2. Lack of resolution and parameter tests.
3. Lack of comprehensive comparisons with observations.

References

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