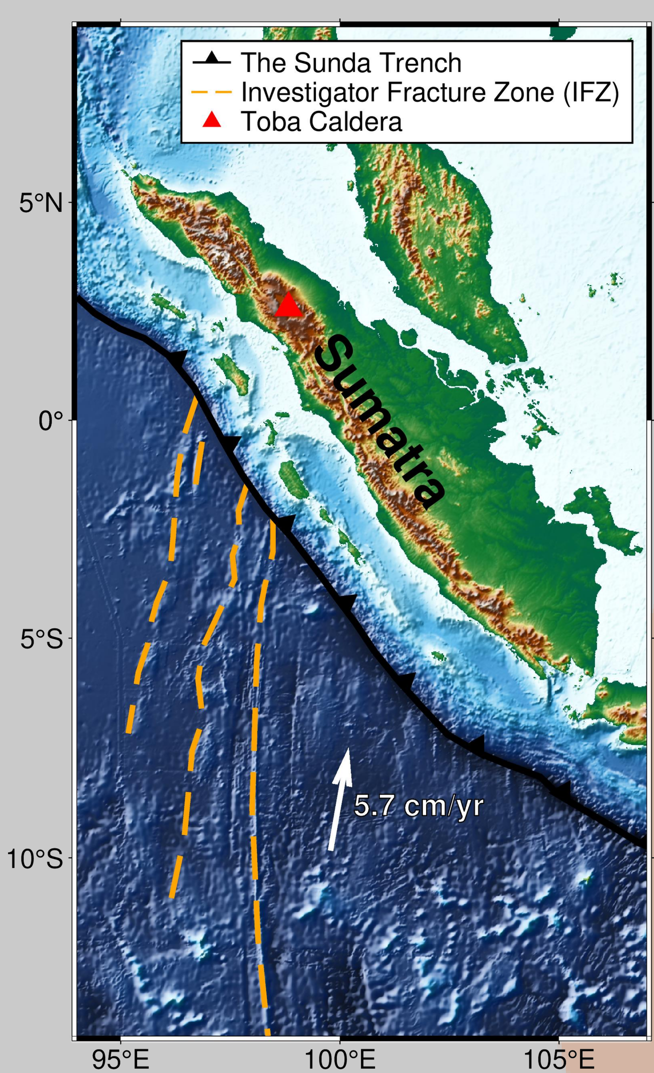
Slab tearing beneath Sumatra:
Insights from 3D numerical modeling

Guangpu Yi[1] and Wei Leng[1]
ygp@mail.ustc.edu.cn
[1]Laboratory of Seismology and Physics of Earth's Interior, School of Earth and Space Sciences, University of Science and Technology of China, Hefei, China

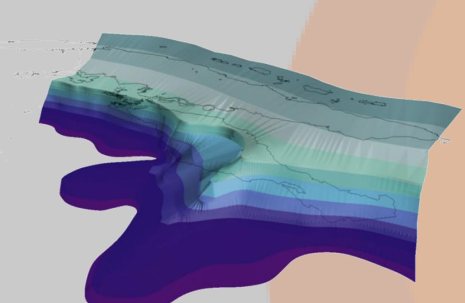
Introduction

The Sumatra Subduction Zone is located at the western margin of Sundaland, characterized by oblique convergence of the Indo-Australian plate. Geologic and geophysical data suggest that there may be a vertical slab tear, a slab folding or a slab window beneath northern Sumatra (Hall and Spakman, 2015; Hu et al., 2023), while tomographic data can't perfectly constrain the existence and detailed structure of the rupture.

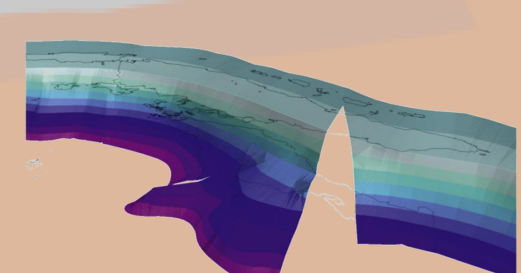
In this study, we test whether comparison of observations to model predictions can distinguish between different slab geometries.



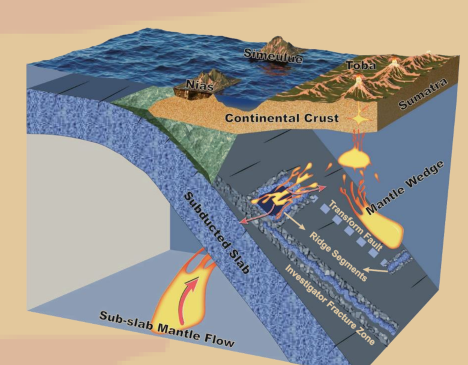
1. slab folding



2. slab tear



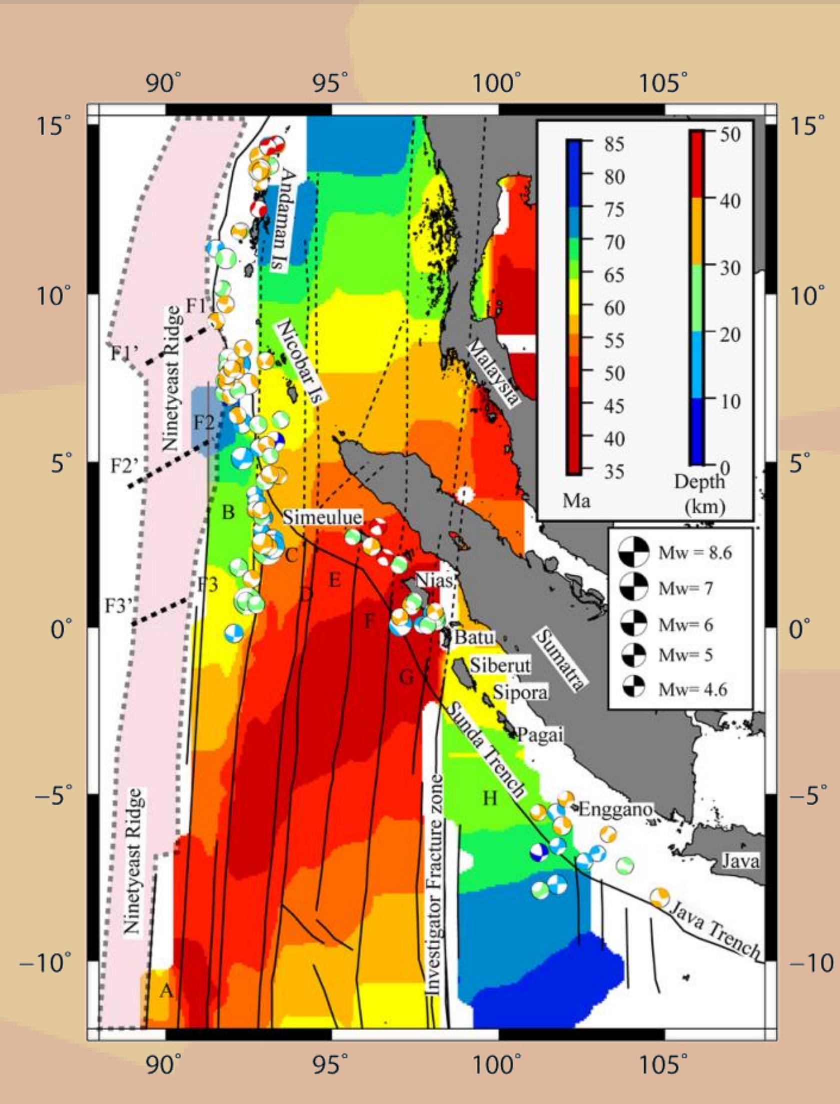
3. slab window

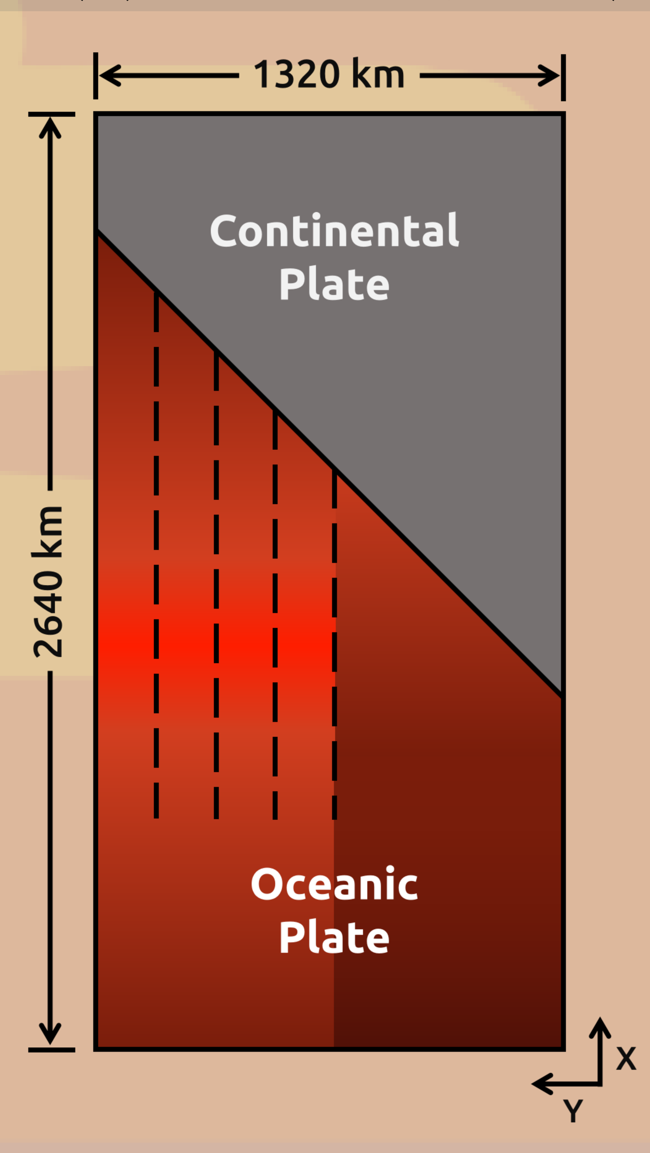


Methods

The 3D geodynamic simulation was 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 2640×1320×660 km³, with a oceanic plate (OP) and a continental plate (CP). The age distribution and rheological weakness of OP are set according to the Wharton Fossil Ridge (reddish area) and the Investigator Fracture Zone (dashed lines) (Jacob et al., 2021).

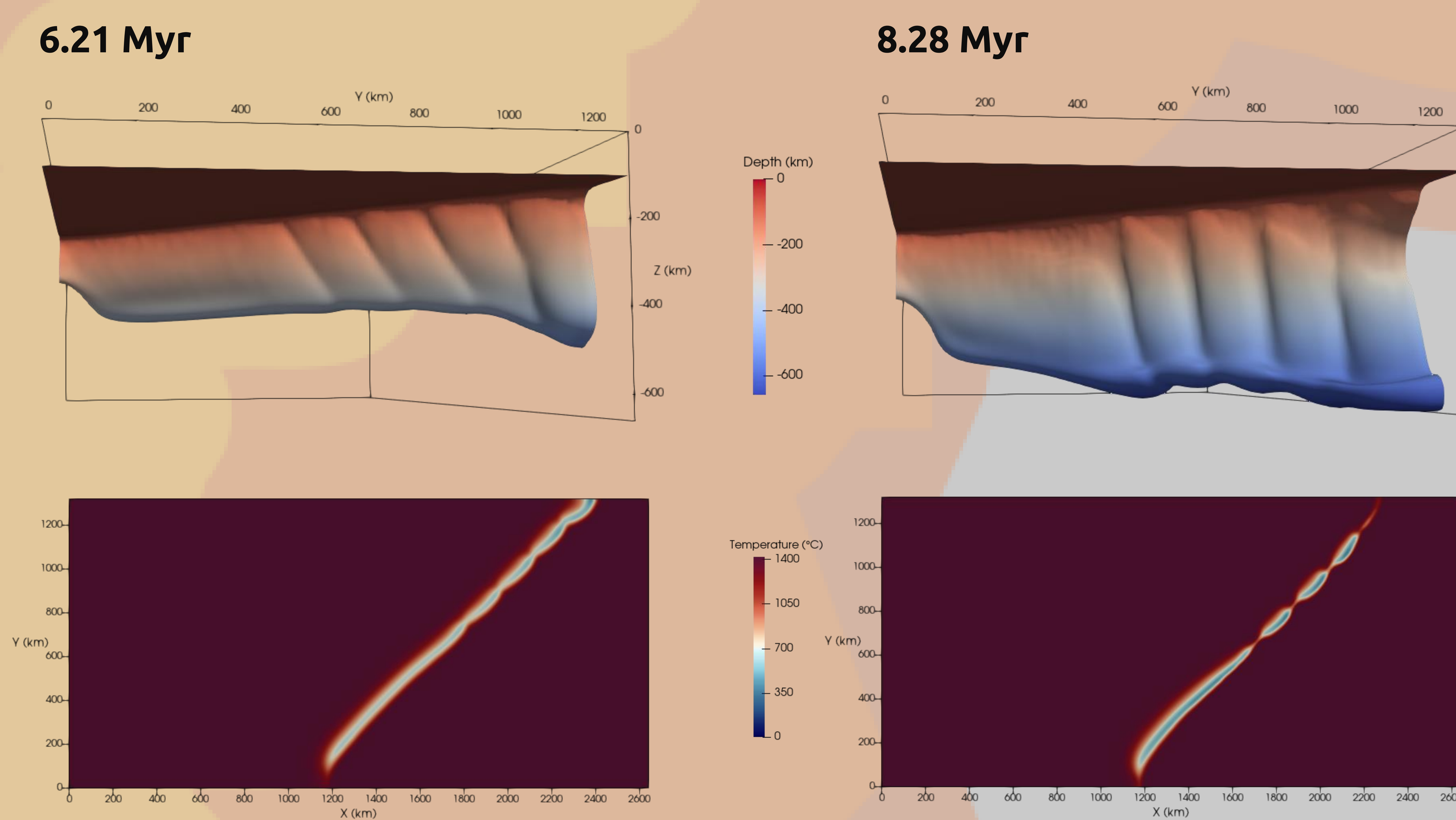




Results

Below shows model evolution at 6.21 Myr and 8.28 Myr. The slab morphology is represented by the 1300 ℃ iso-temperature contour (seen from the overriding plate), with color indicating the depth. The second row show temperature distributions at 250 km deep.

Before ~6.21 Myr, we can see from the shadowed areas that the slab is slightly thinned at fracture zones, but a rupture has not formed yet. At 8.28 Myr, when the well-subducted slab begins to detach due to its sufficient negative buoyancy, it tears vertically at the weak zones.



Discussion

Using 3D numerical simulations, we found that oceanic plate with fossil ridge that died ~30 Ma may not tend to break off at its spreading centers during subduction. Slab's vertical tearing during horizontal detachment is mainly caused by oblique subduction of the dead transform faults.

Nevertheless, as a preliminary attempt, there exist lots of limitations in our work:
1. Model simplification, including tectonic history, setup of the fossil ridge, driving mechanism of subduction, etc.
2. Lack of resolution and parameter tests.
3. Lack of comprehensive comparisons with observations.

References

Hall, R., & Spakman, W. (2015). Mantle structure and tectonic history of SE Asia. Tectonophysics, 658, 14–45. https://doi.org/10.1016/j.tecto.2015.07.003

Hu, H., Zhao, D., Lin, J., & Pilia, S. (2023). A slab window beneath North Sumatra revealed by P-wave mantle tomography. Journal of Geophysical Research: Solid Earth, 128, e2022JB025976. https://doi.org/10.1029/2022JB025976

Leng, W., & Gurnis, M. (2015). Subduction initiation at relic arcs. Geophysical Research Letters, 42(17), 7014–7021. https://doi.org/10.1002/2015gl064985

Jacob, J., Dyment, J., Ghosal, D., & Dewangan, P. (2021). Strike-slip seismicity at the Andaman-Sumatra Subduction Zone: Role of the fracture zones and age of the subducting lithosphere. Tectonophysics, 811, 228862. https://doi.org/10.1016/j.tecto.2021.228862