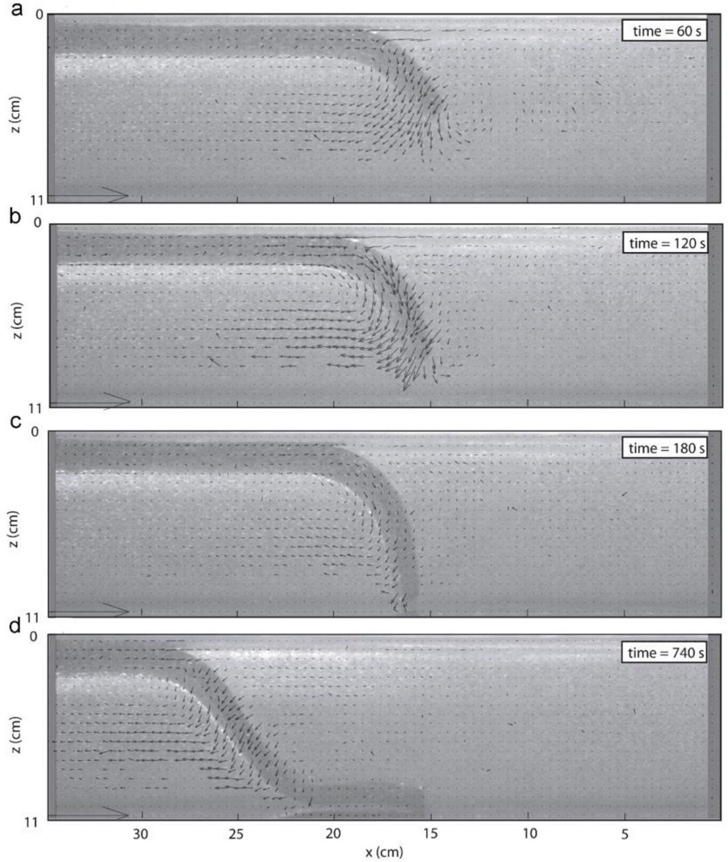
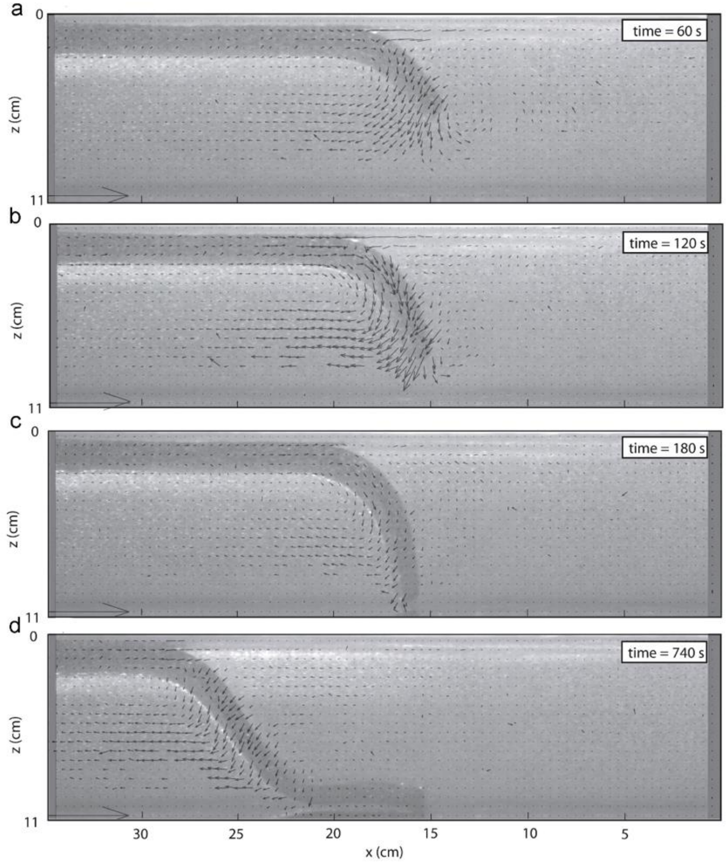
Overriding plates and plate interfaces

No OP models



E.g., the analog models we discussed recently (e.g., Funiciello et al., 2006)

No OP models



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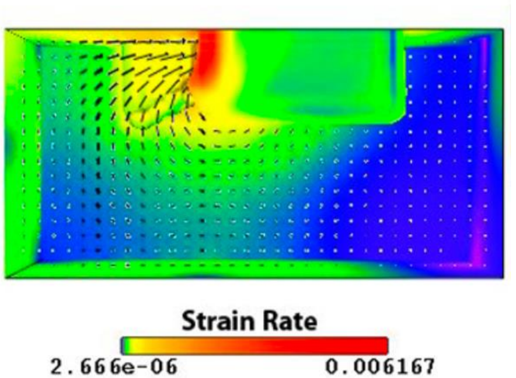
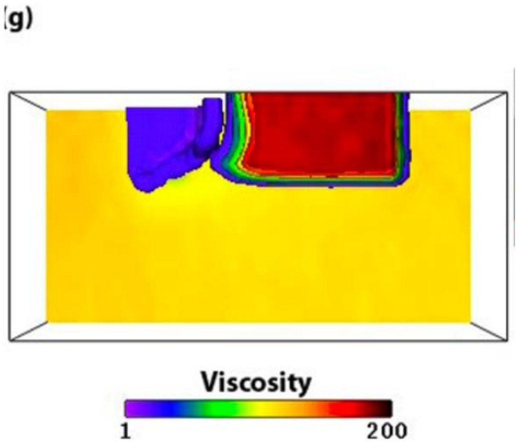
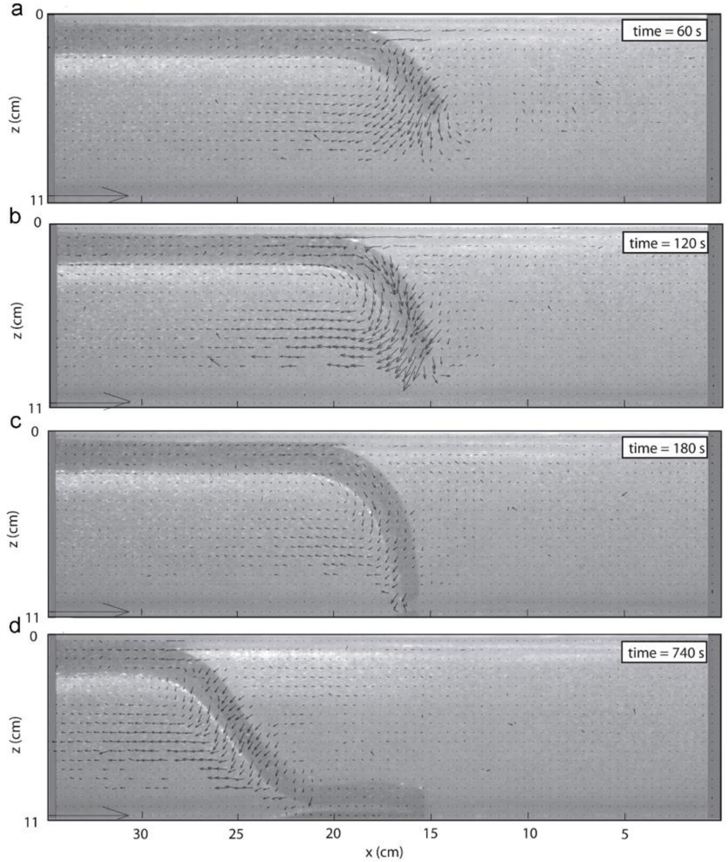
And older 2-D and 3-D numerical models (this one: Stegman et al., 2006)





No OP models



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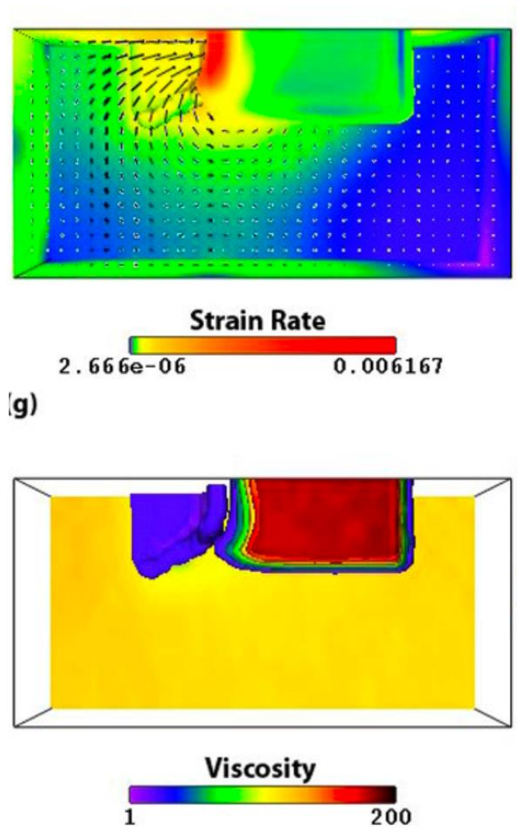

- *Simplify the forces acting on subduction zones (no upper plate basal shear, interface shear highly simplified, large mantle wedge corner)!*
- *Cannot be used to investigate upper plate deformation/topography!*

1. OP effects on slab behavior, mantle flow, stress state

2. Plate interface effects

3. Plate interface stress state (Beall et al., 2021)

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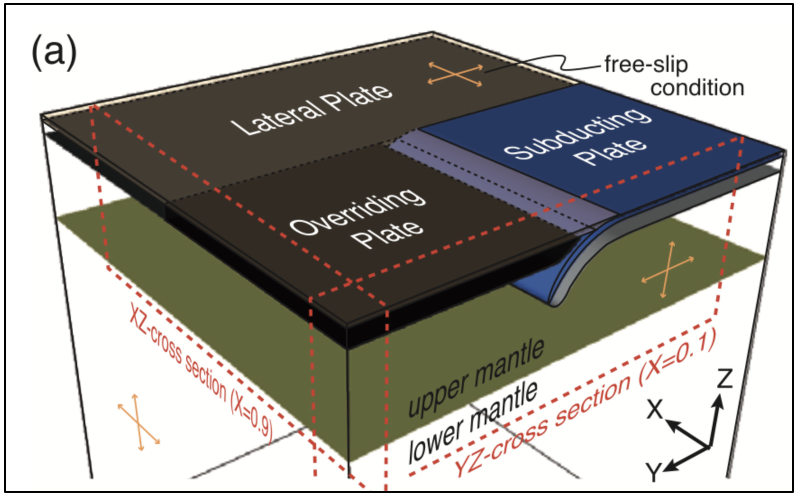
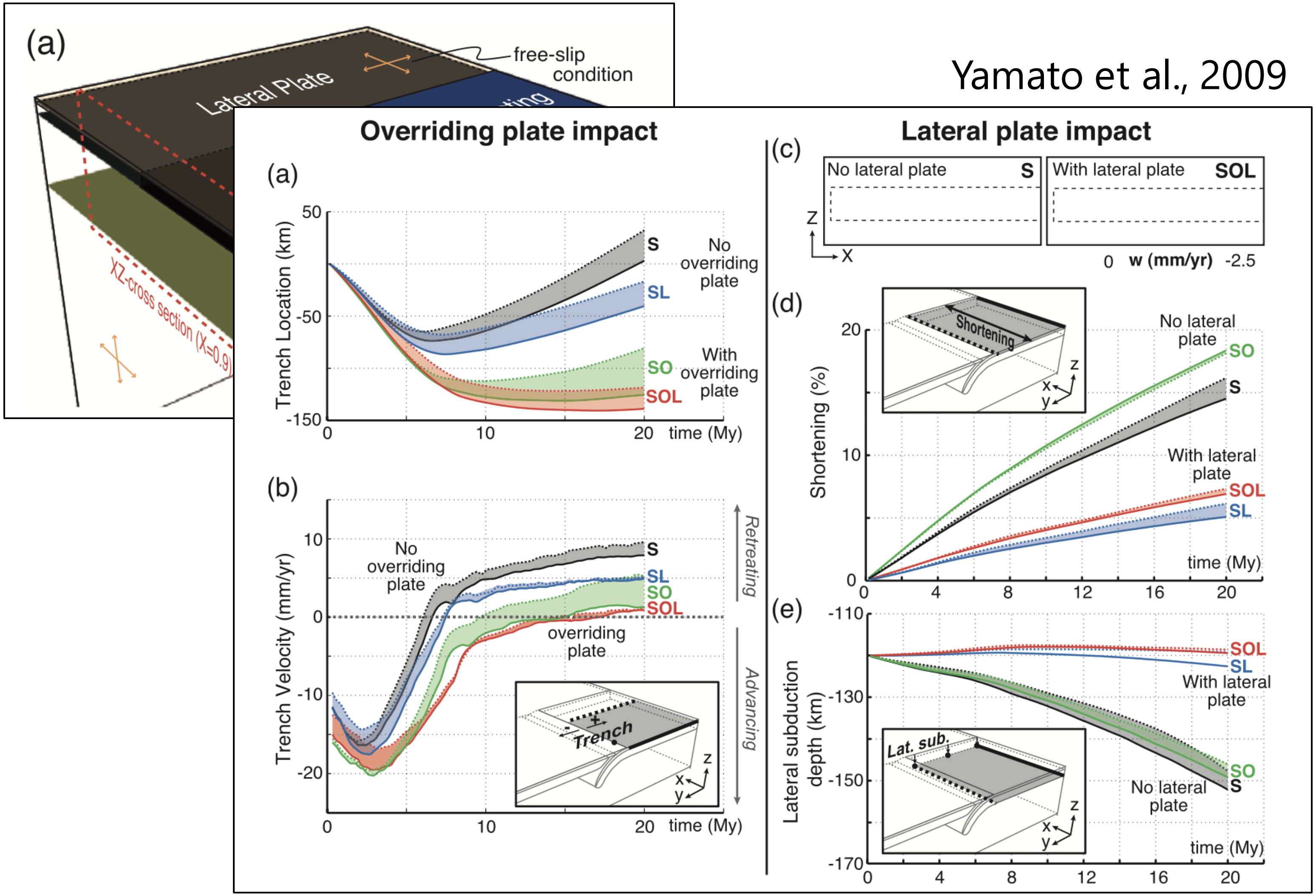
Overriding plate impact on rollback



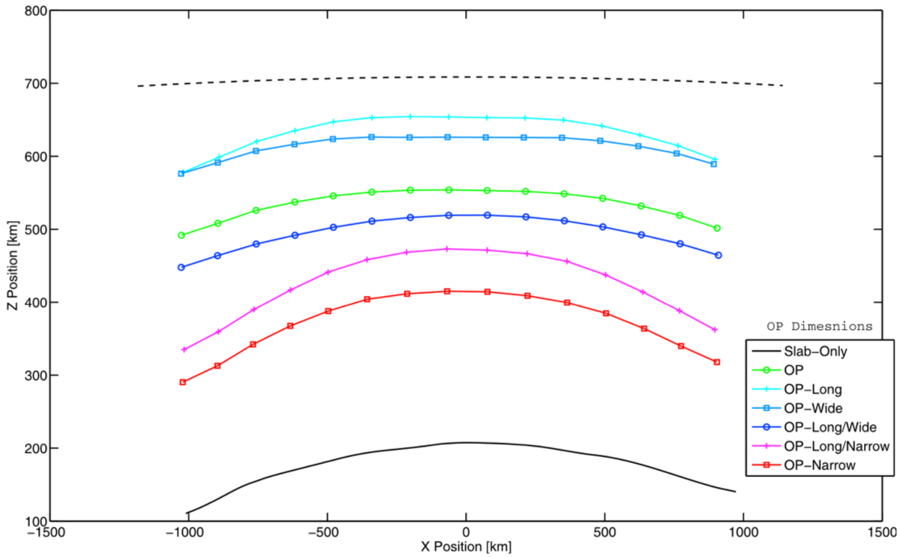
Overriding plate impact on rollback

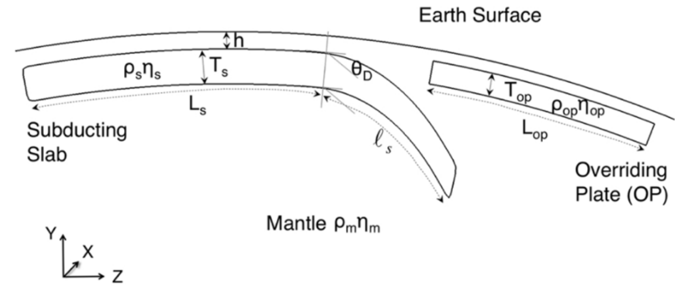
Yamato et al., 2009



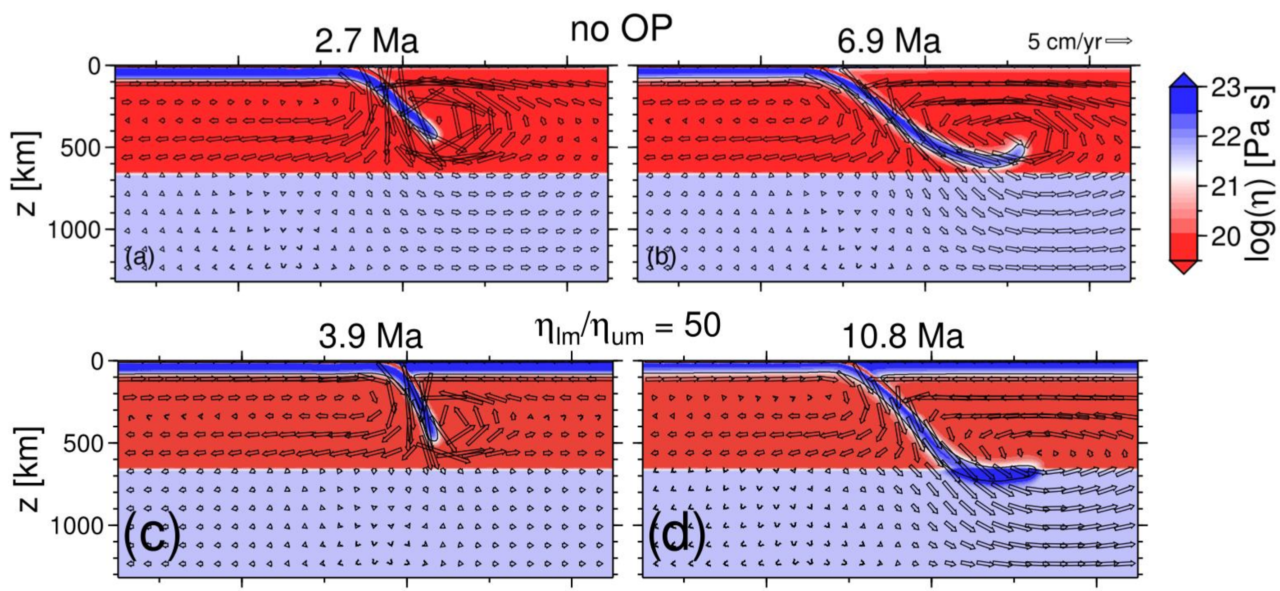
- *Overriding plate reduces slab rollback velocities (but minimal effect on convergence rate).*
- *Lateral "side" plates important to limit trench parallel shortening.*

Butterworth et al., 2012, G^3



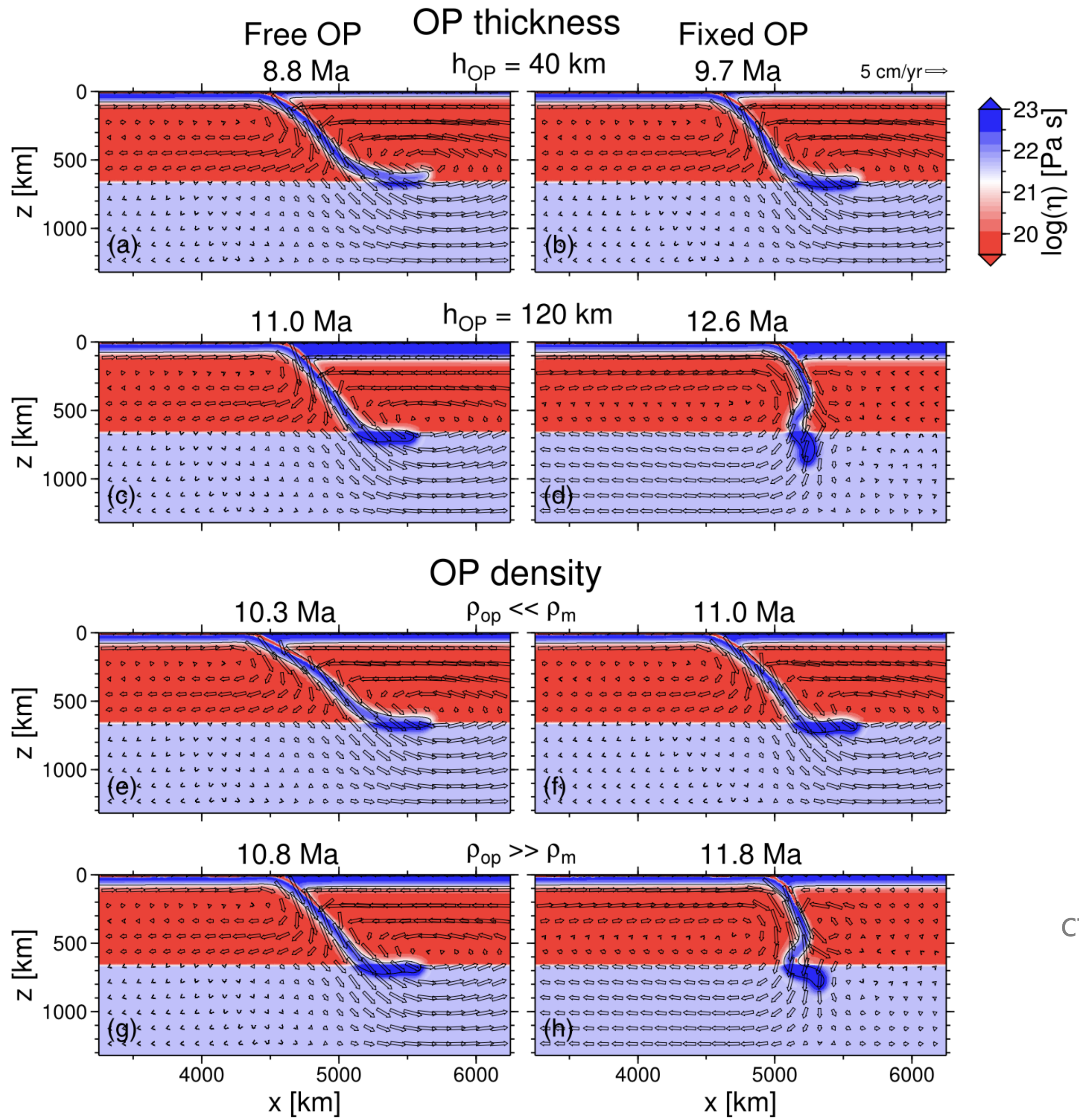


Consistent with more recent studies



Holt et al., 2015

Overriding properties also have strong effect

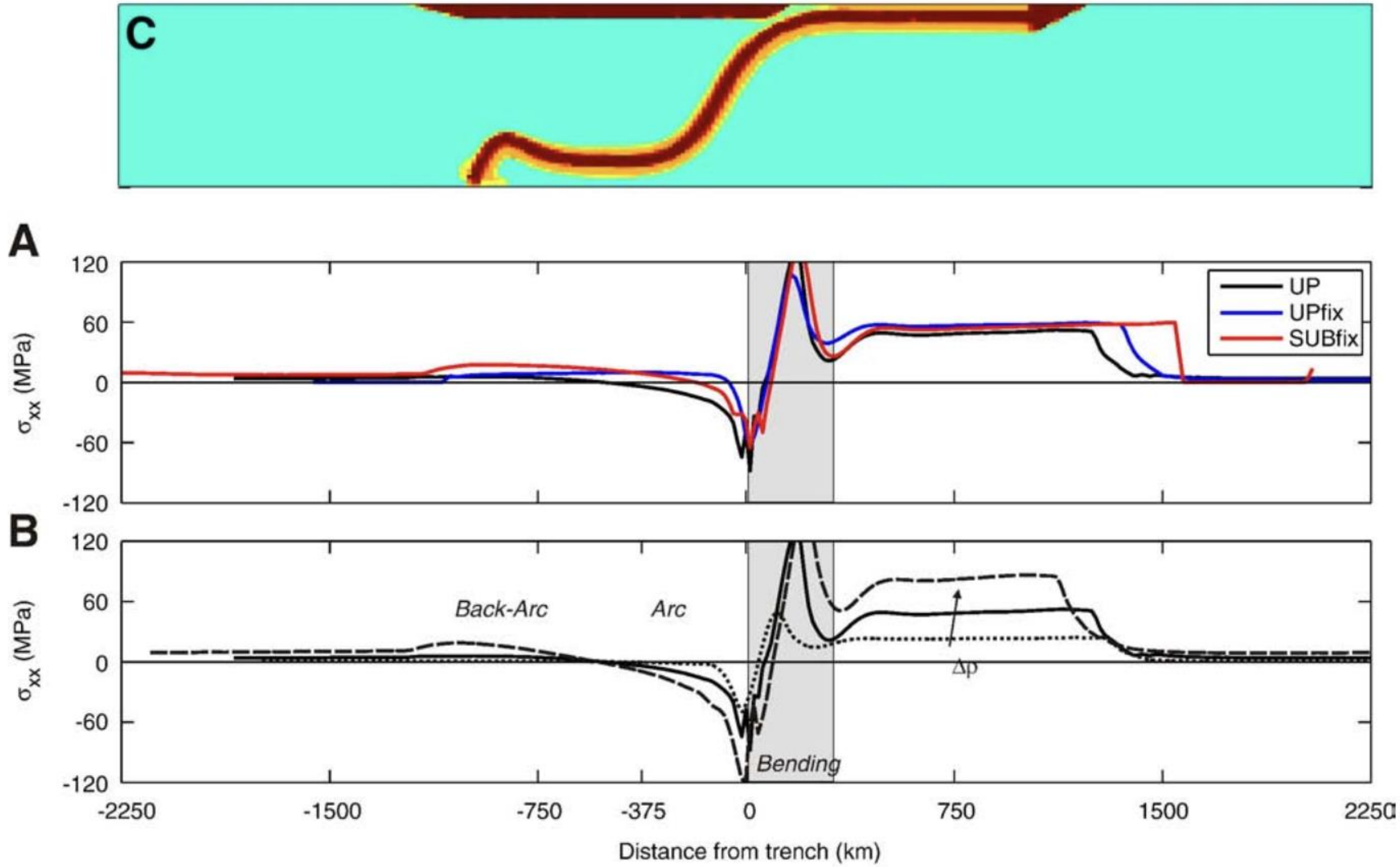


Holt et al., 2015

cf. van Dinther et al., 2010;
Capitano et al., 2010;
Sharples et al., 2014

Overriding plate tectonics/stress state

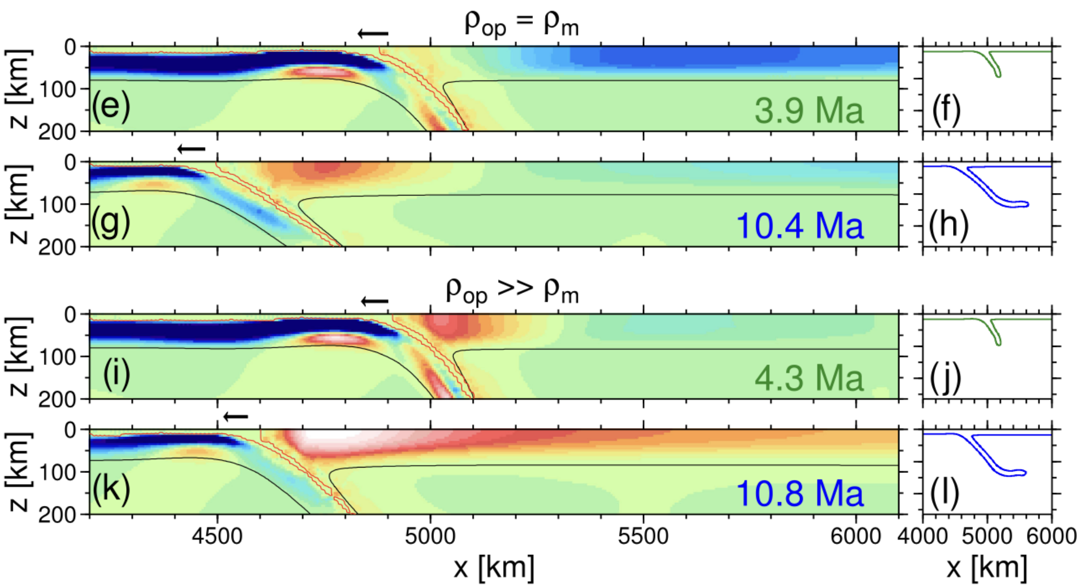
Capitanio et al., 2010



Dictated by basals traction on the upper plate, negative pressure in the mantle wedge, and possible stress transferred through the interface.

Overriding plate tectonics/stress state

Lots more work since…

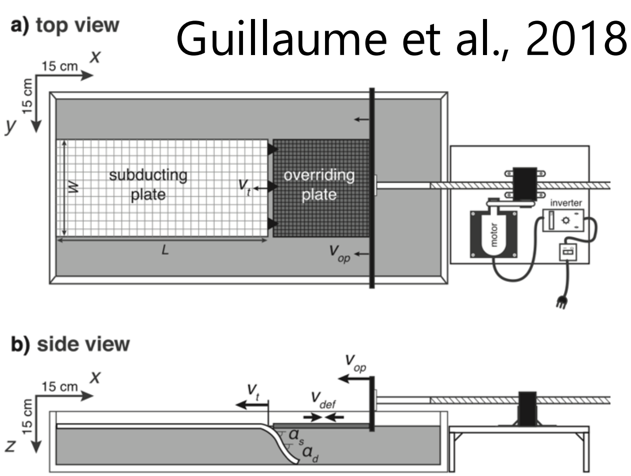


e.g., as a function of upper plate properties

Holt et al., 2015

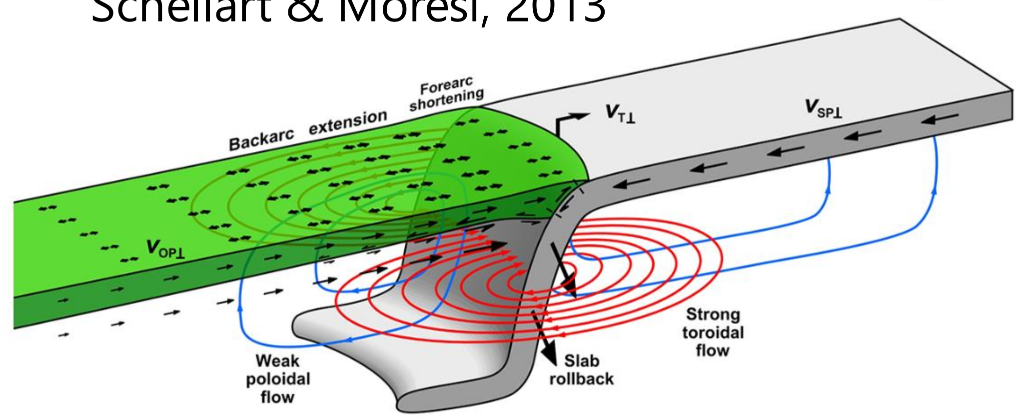
e.g., far-field upper plate forcing

Guillaume et al., 2018

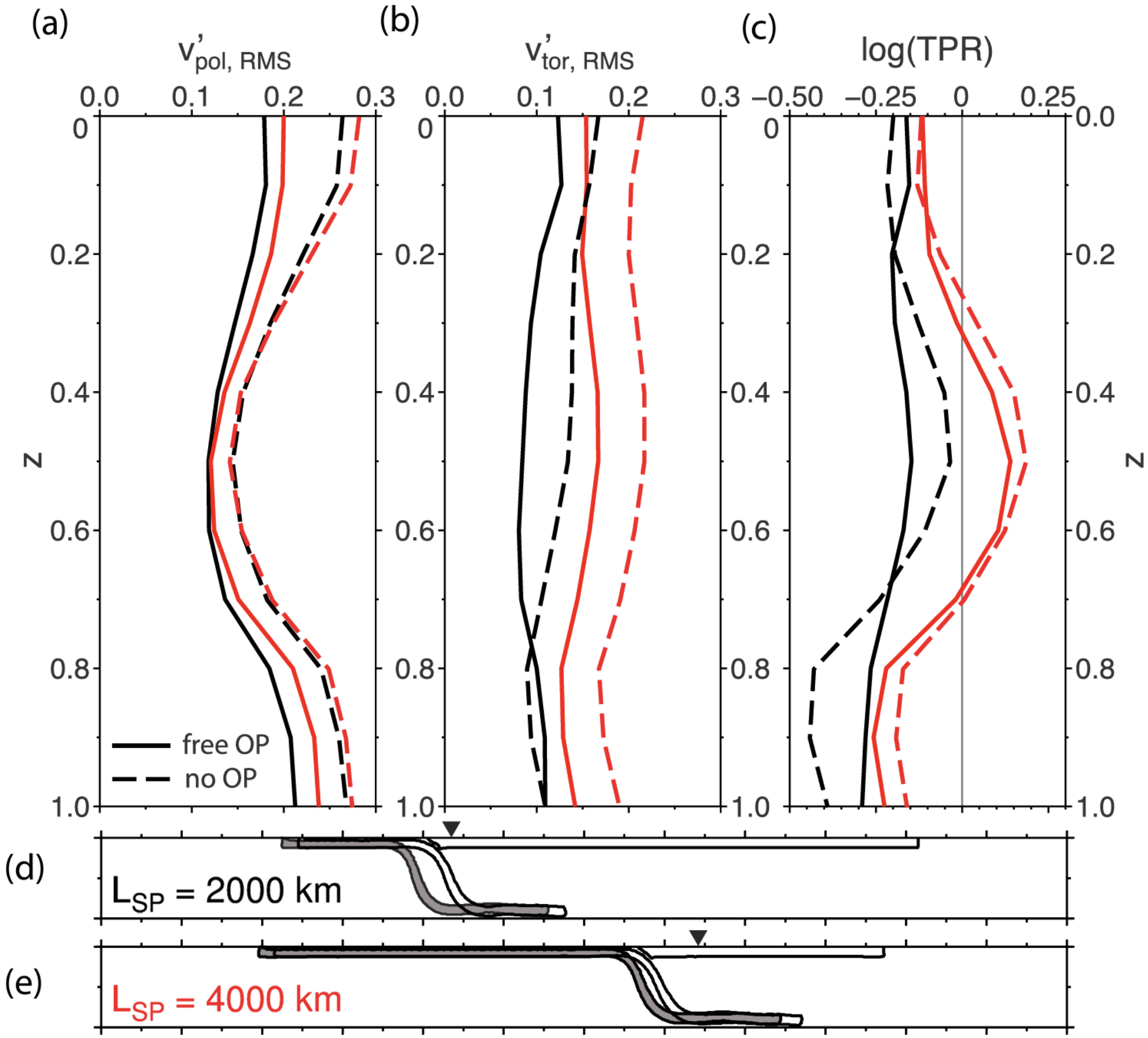


e.g., 3-D effects

Schellart & Moresi, 2013



Mantle flow regime



TPR reduced by inclusion of upper plate (relates to the reduced rollback shown in earlier studies)

Holt and Becker, 2017

1. OP effects on slab behavior, mantle flow, stress state

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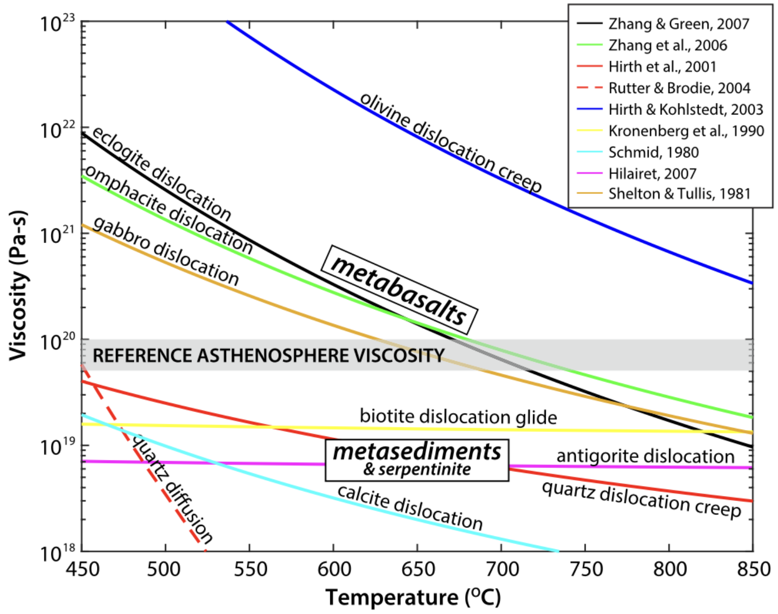
Impact of viscous shear zone strength on plate speeds

Behr and Becker, 2018



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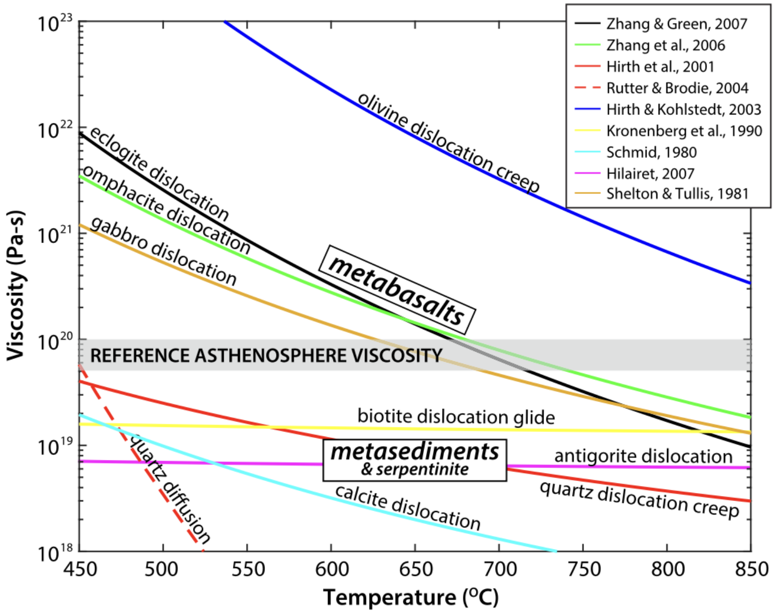

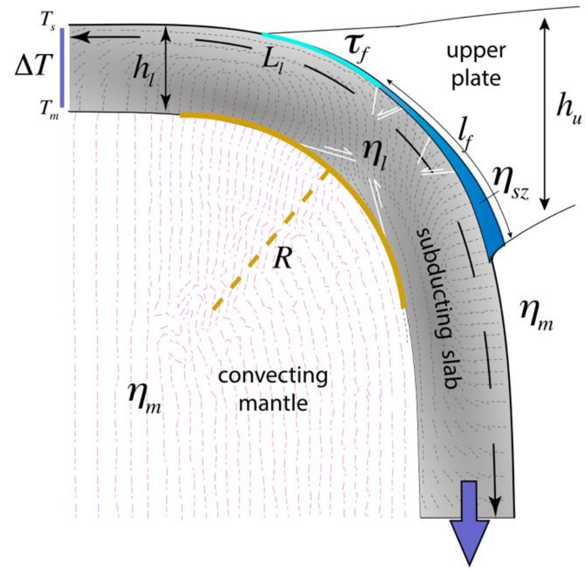

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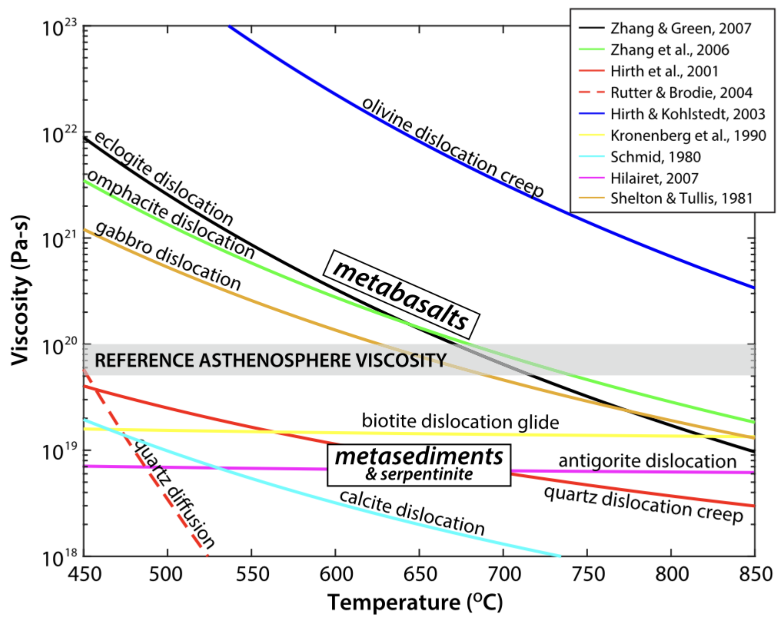

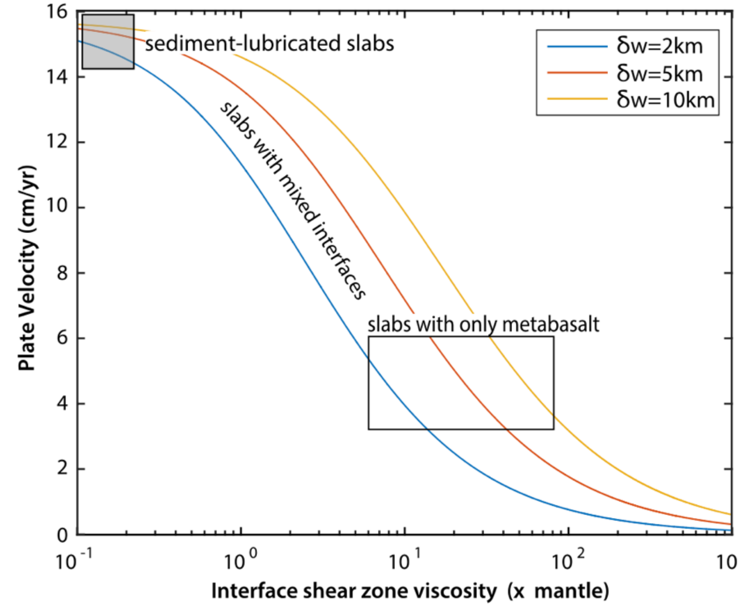

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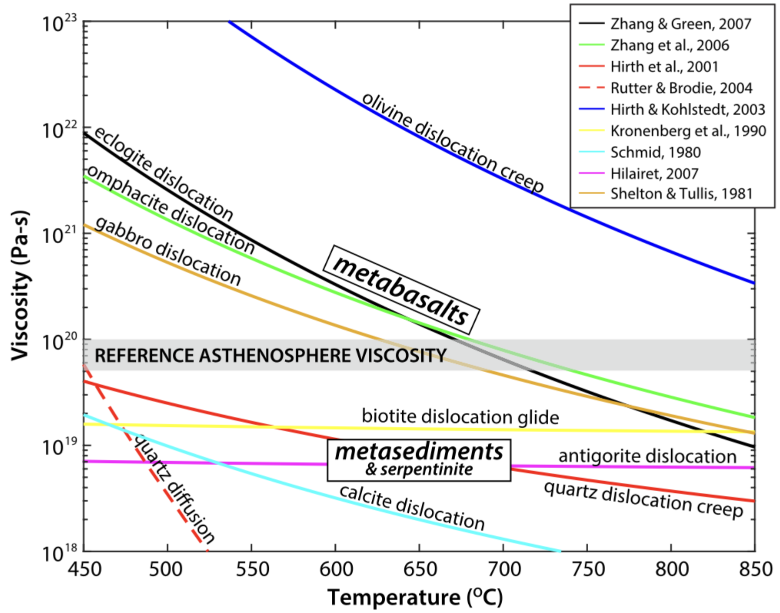
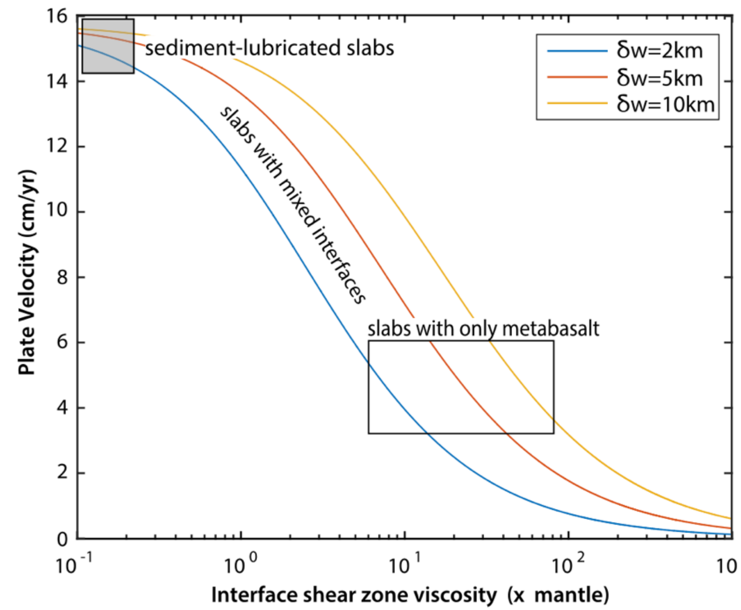
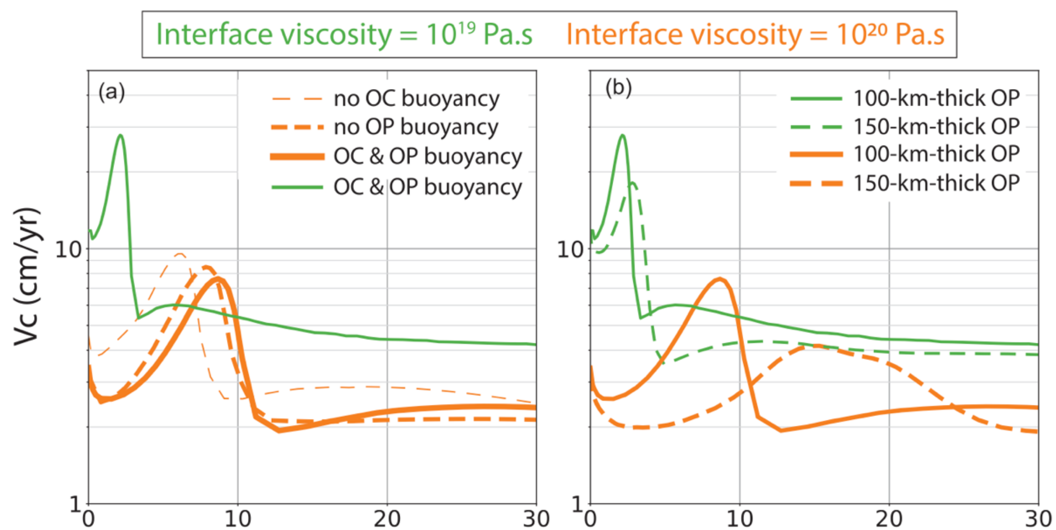




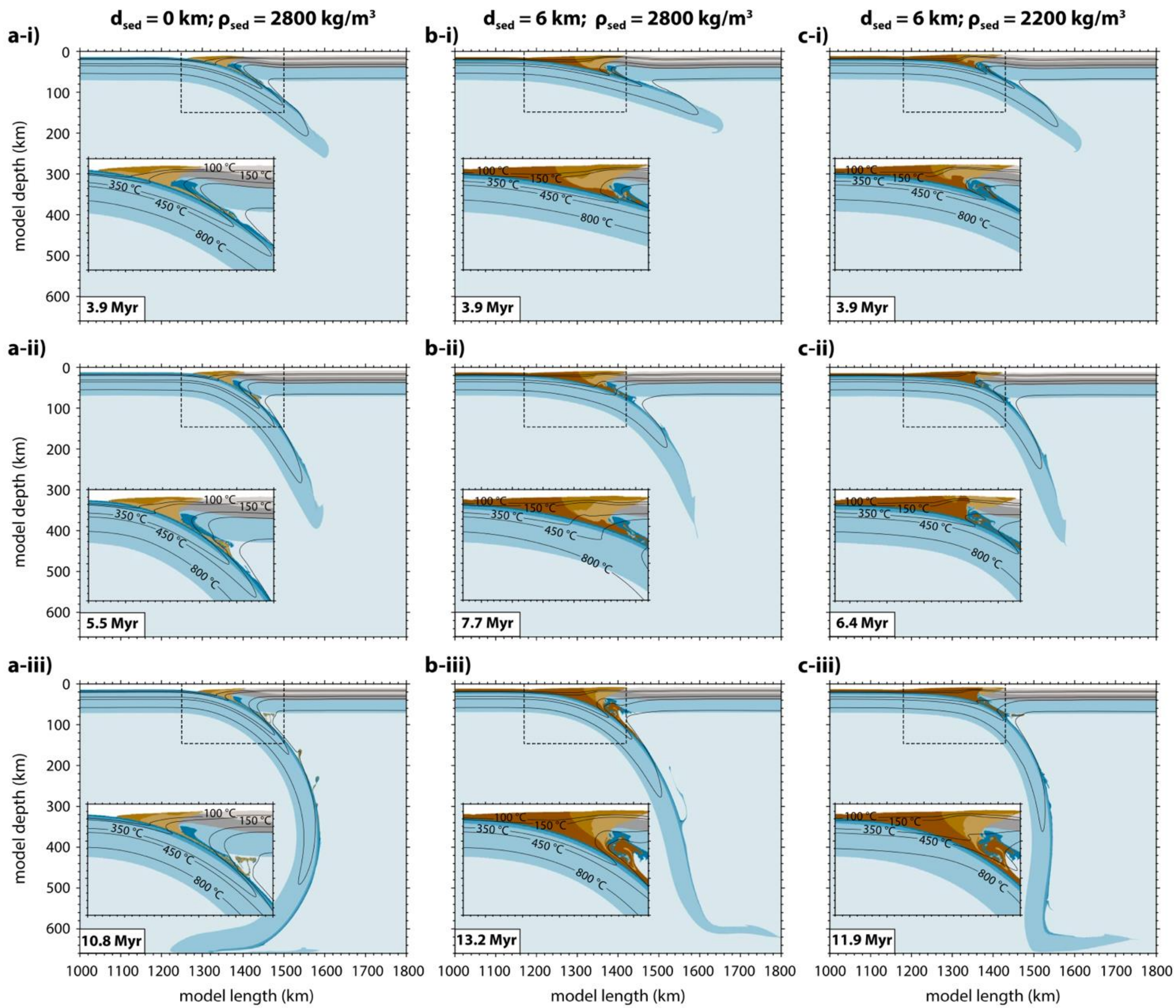


Numerical:

Also, a significant effect on rollback, upper plate stress, topography

Behr et al., 2022

Impact of viscous shear zone strength on plate speeds



Brizzi et al., 2021: Thick sediments are light and cover more of the slab top – may actually slow things slow down

1. OP effects on slab behavior, mantle flow, stress state

2. Plate interface effects

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What governs the long-term stress on the interface? And how/does this link to great earthquakes?

VOL. 84, NO. B3 JOURNAL OF GEOPHYSICAL RESEARCH MARCH 10, 1979

Back-Arc Opening and the Mode of Subduction

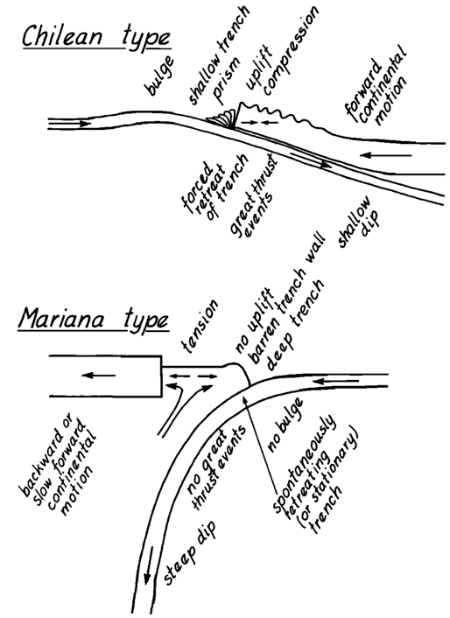
SEIYA UYEDA

Earthquake Research Institute, University of Tokyo, Tokyo, Japan

HIROO KANAMORI

Seismological Laboratory, California Institute of Technology, Pasadena, California 91125

Trench-arc systems (subduction zones) can be classified into two types depending on whether or not actively opening back-arc basins are associated with them. This suggests that subduction of an oceanic plate is not a sufficient condition for back-arc opening, though it may be necessary one. Mechanisms that cause the distinction between the two types have been investigated. Earthquake studies suggest that there is a significant difference in the mode of plate motion at interplate boundaries between the two types of trench-arc systems. Extreme cases are Chile, where plate motion is seismic, and the Marianas arc, where it is aseismic. This difference seems to indicate that the stress state in the back-arc area differs between the



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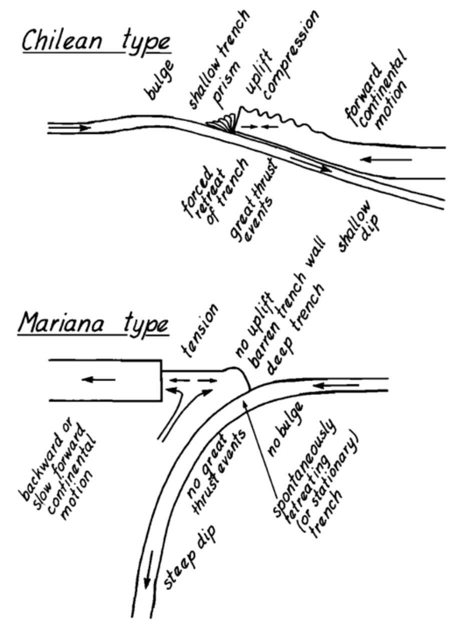
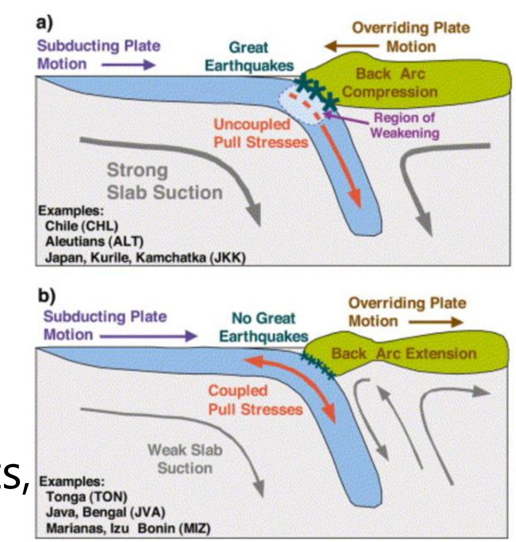


Earth and Planetary Science Letters

Volume 218, Issues 1–2, 30 January 2004, Pages 109-122

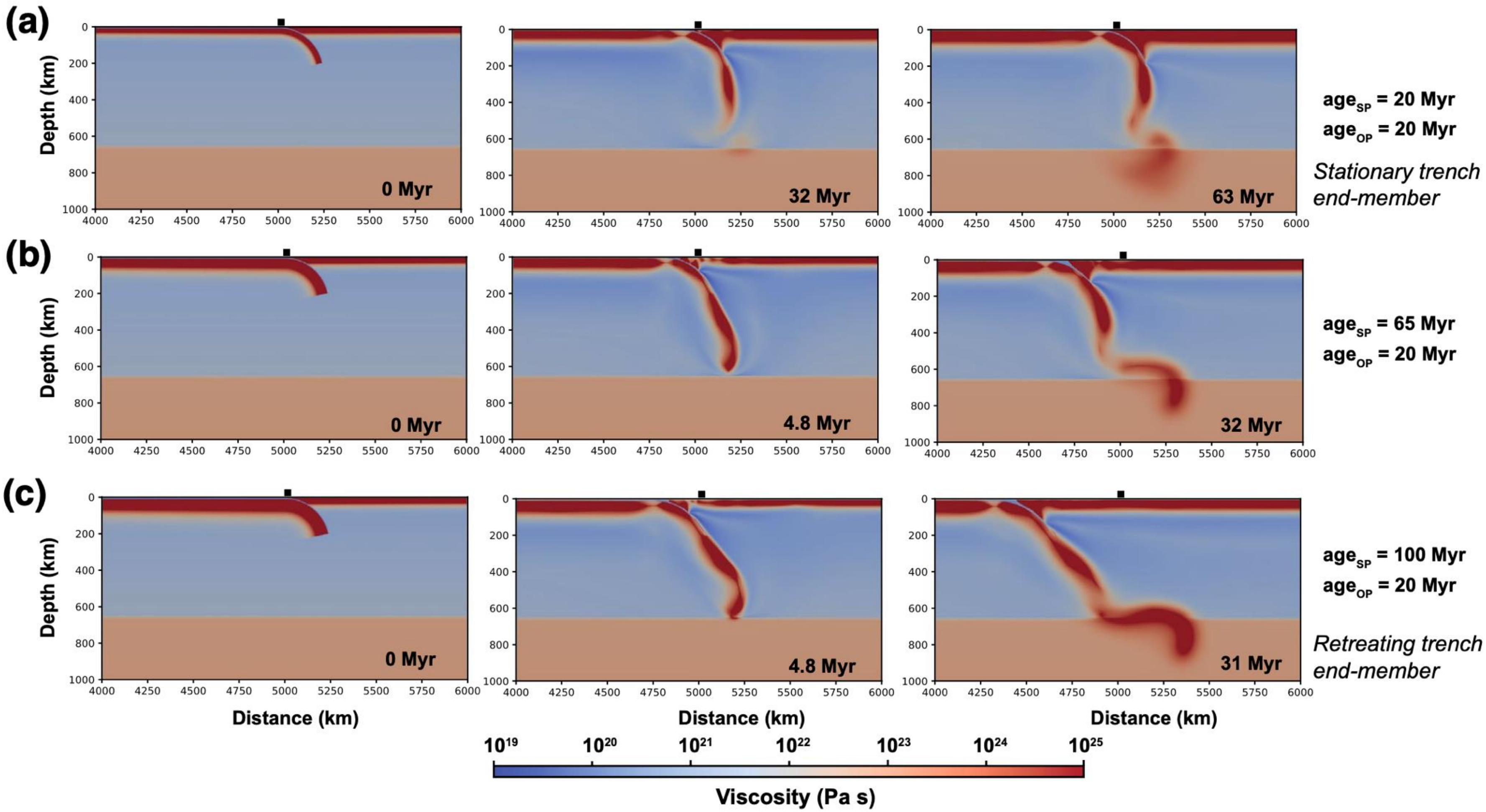
Great earthquakes and slab pull: interaction between seismic coupling and plate–slab coupling

Clinton P. Conrad, Susan Bilek[1], Carolina Lithgow-Bertelloni



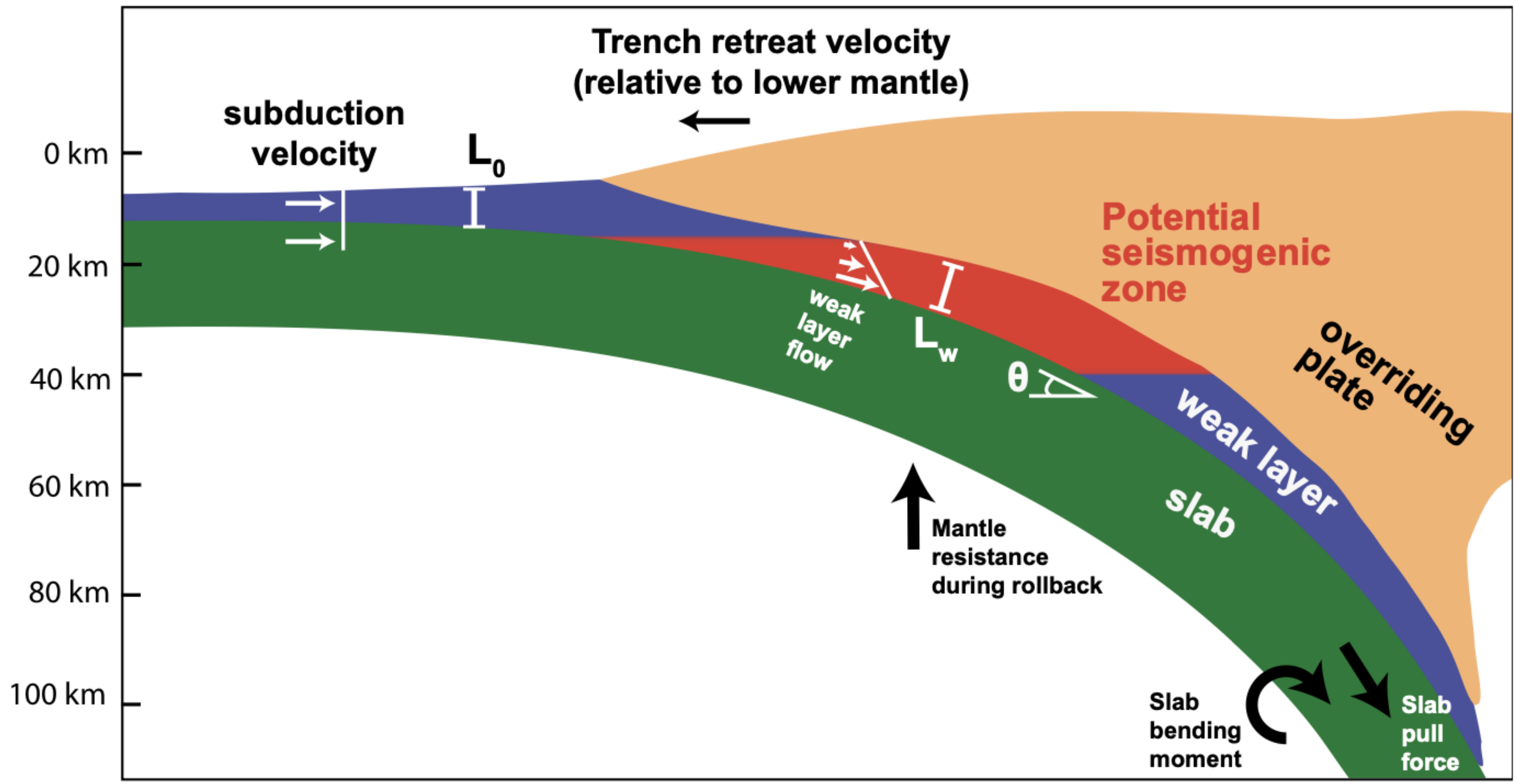
Conrad: Seismically coupled SZs, which produce great events, associated with decoupled/detached slabs (maybe…)

Dynamic models considered (from Garel et al., 2014)

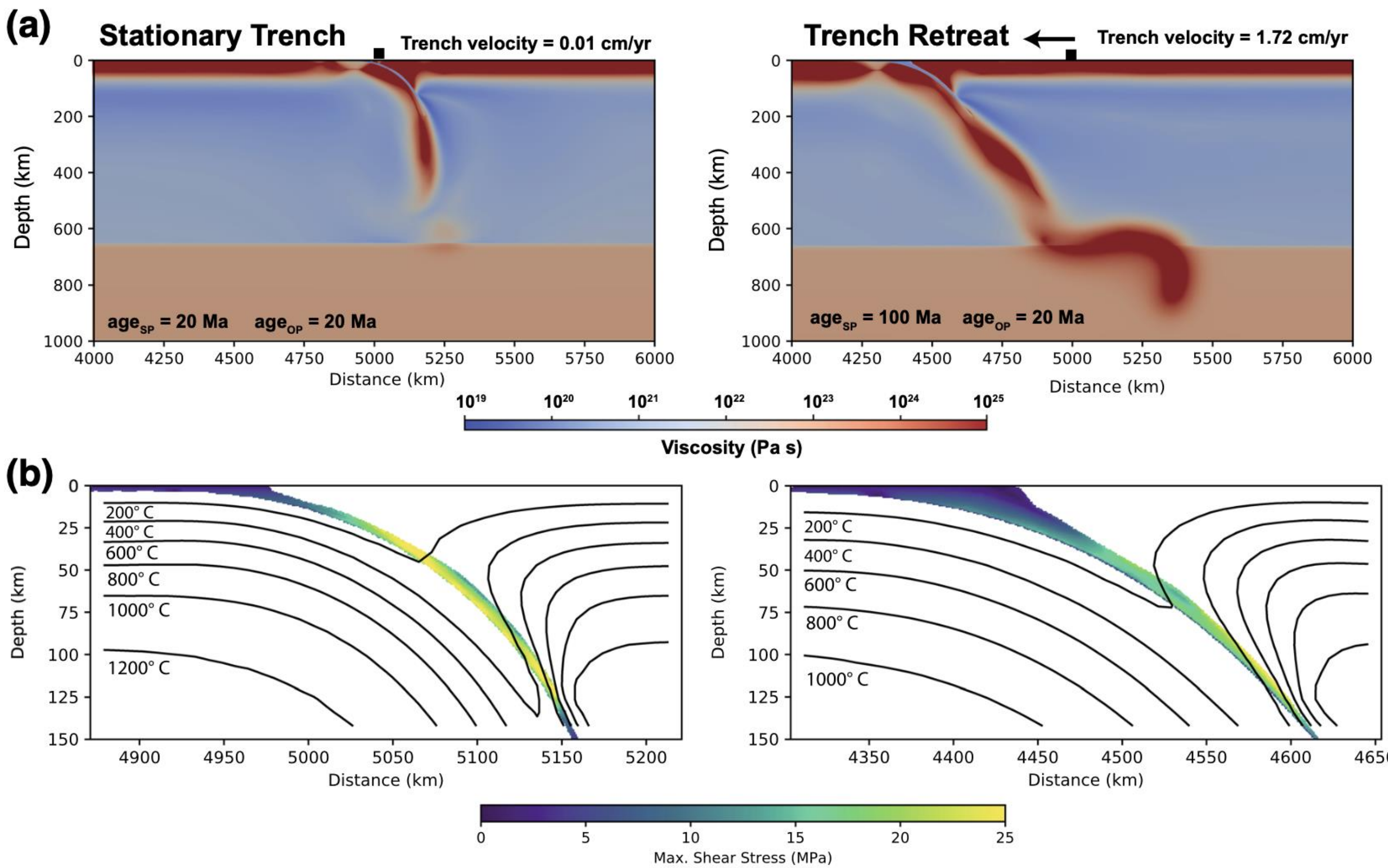


<u>Idea</u>: Look in detail at interface stresses within dynamic models with variable slab rollback rates. Relationship between stress state and seismogenesis?

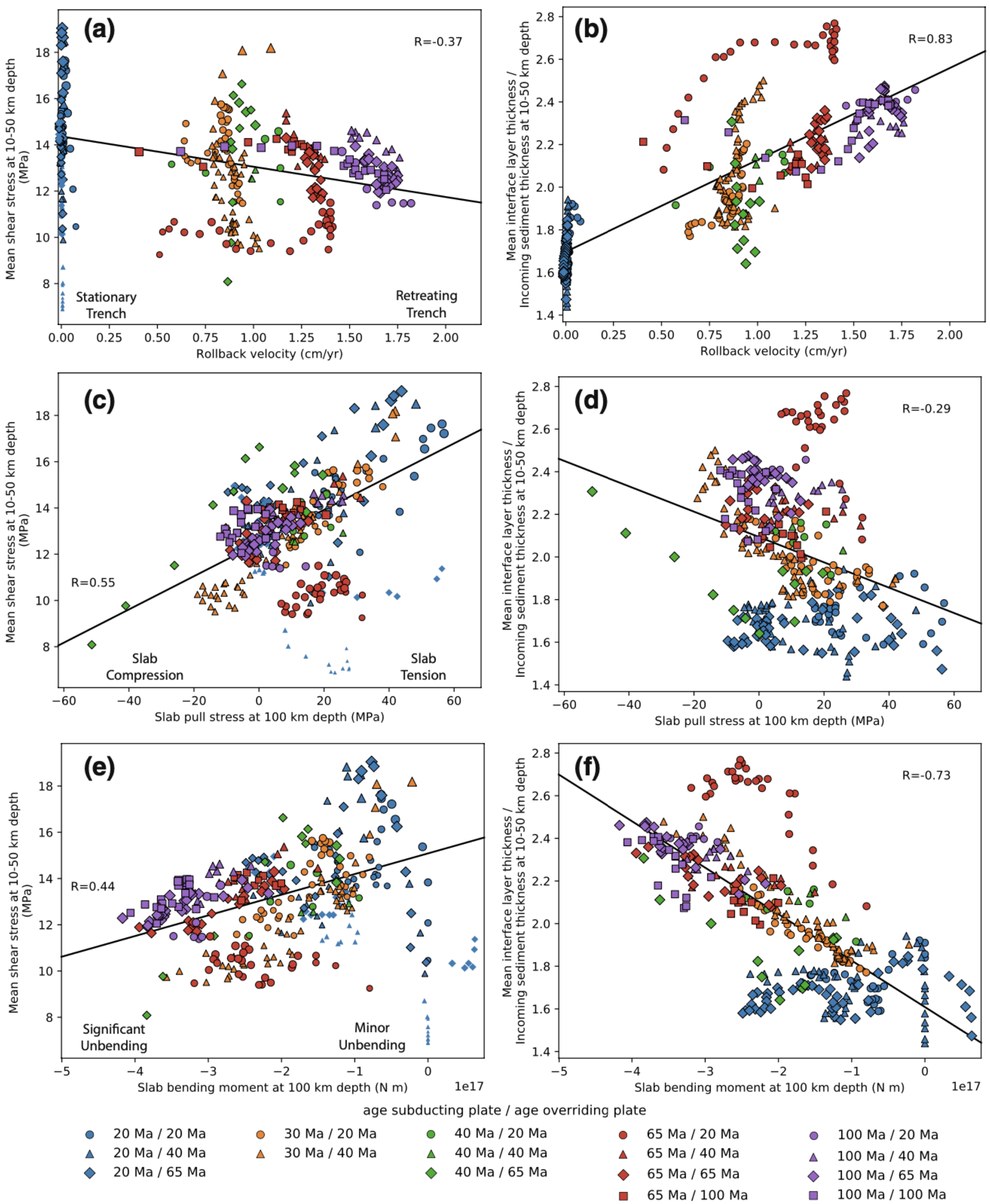
How is the interface stress (particularly at seismogenic depths) related to slab dynamics, if at all?



Resolving the shear stress in the subduction channel / along the interface



All their models



- Shear stress decreases with rollback (rollback thickens the channel).
- Shear stress increases with slab pull (drags the material down more rapidly); e.g., low shear stress before the slab hits 660-km.
- Shear stress decreases with slab unbending/increases with slab bending. Bending modifies interface thickness, which induces P gradients.

Potentially estimable using earthquake mechanisms. Bending/unbending seems to match aseismic/seismic characteristics, but just at some subduction zones.

Proposed relationship between interface shear and v_T

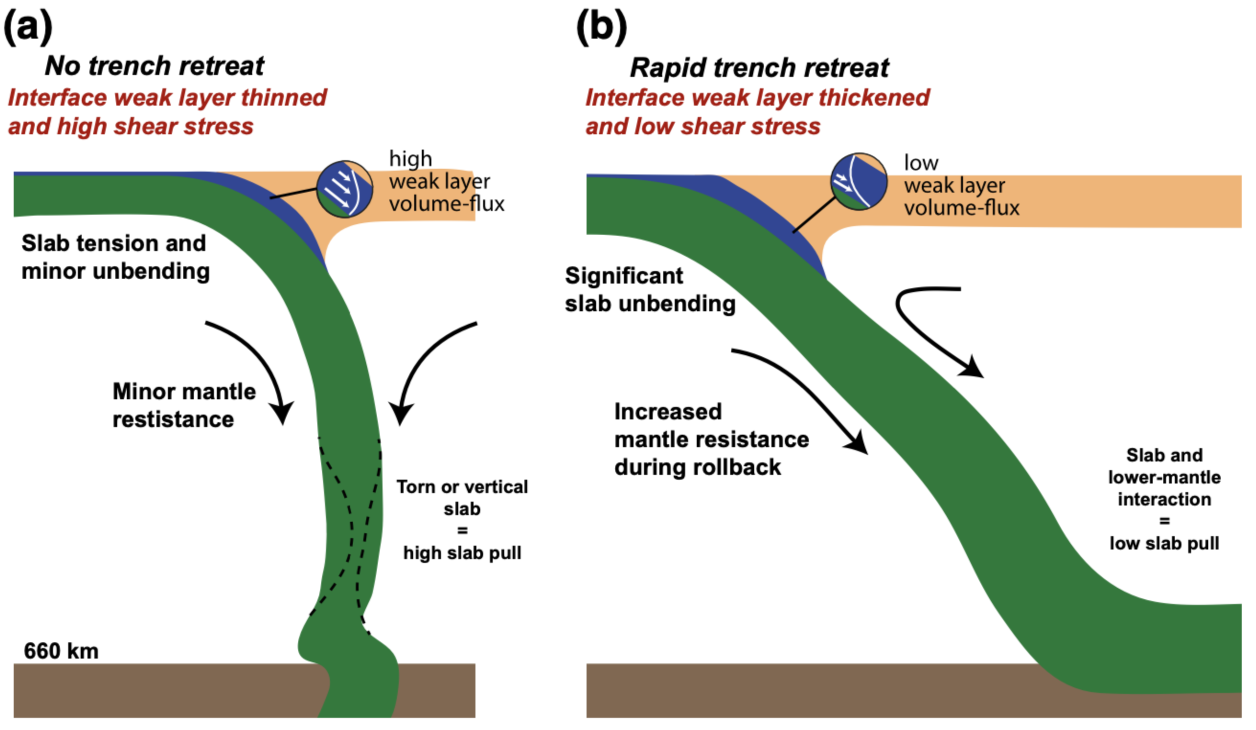
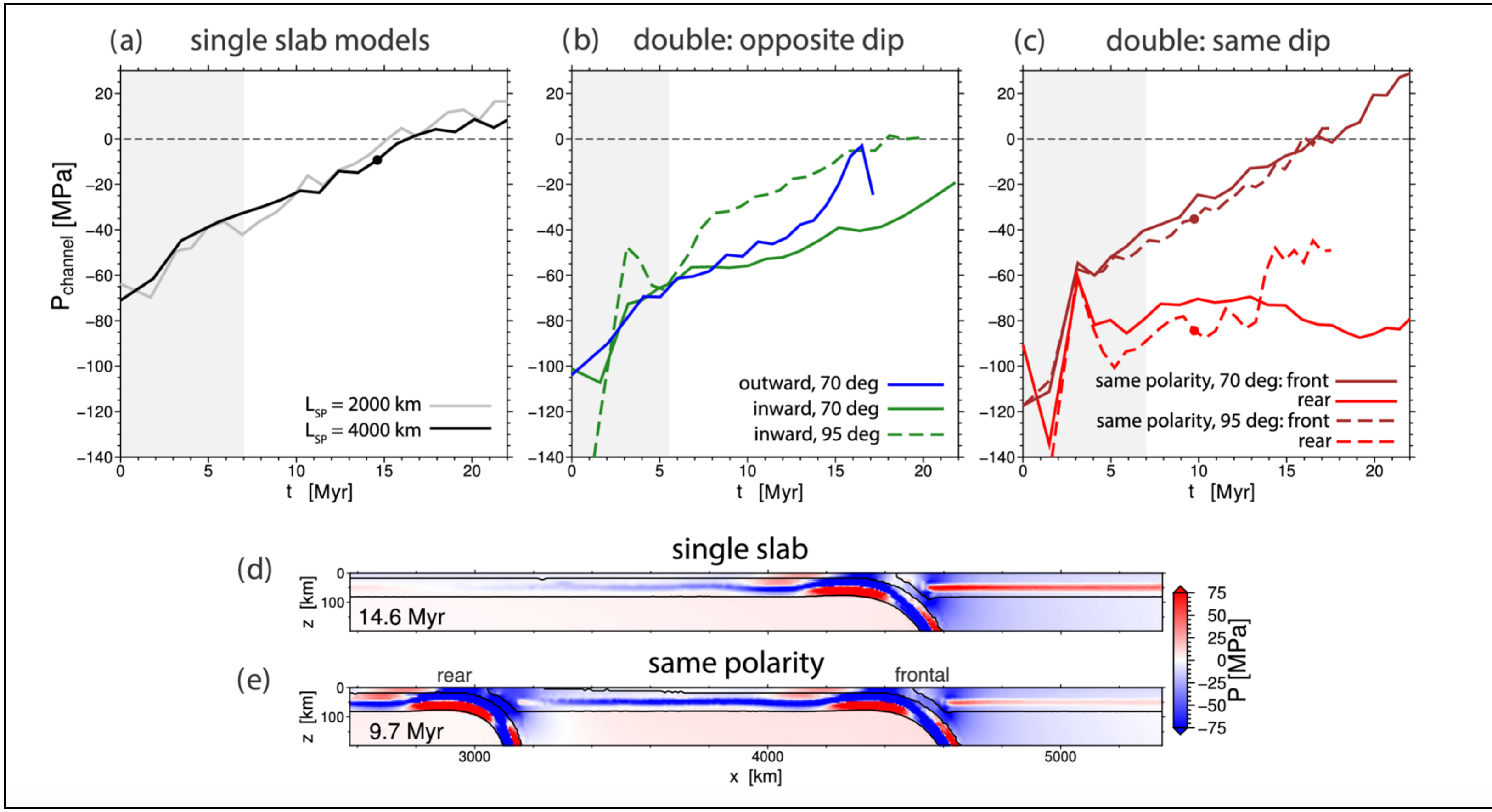


Figure 8. Summarized behavior proposed in this study, linking slab evolution and morphology to interface shear stress (not to scale) for the negligible (a) and rapid (b) trench retreat end-members.

"Further modeling is required to quantify how this long length- and time-scale stress influence interacts with the earthquake cycle, as well as other critical influences on fault stress, such as fluid pressure, trench sediment thickness and heterogeneity of frictional fault-zone properties."

Related, but simpler, tests for double subduction

Holt et al., 2018



- Lowest pressure in the rear slab interface (due to slab pull from frontal subduction zone).
- Related to low seismic coupling @ Izu-Bonin-Mariana?

Megathrust – slab dynamics links is a hot topic (and hard to model properly!)

e.g.:

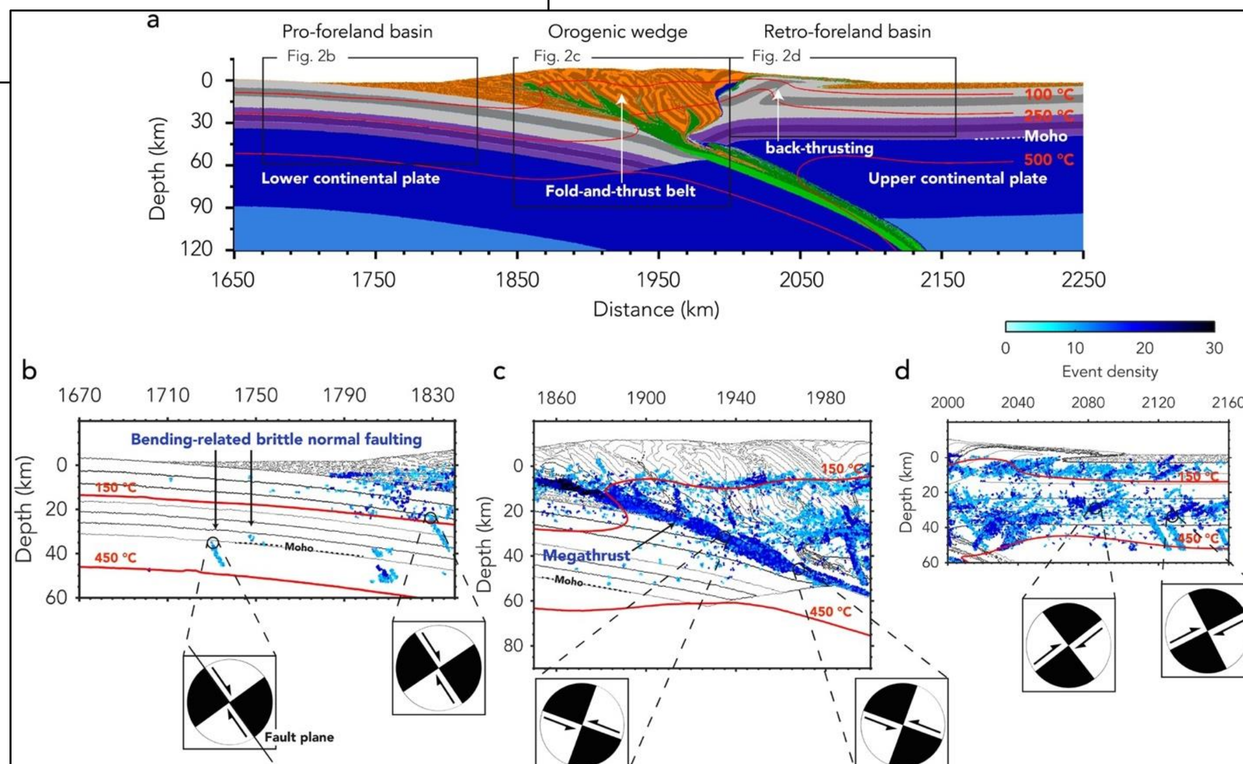
Earth and Planetary Science Letters
Volume 482, 15 January 2018, Pages 81-92

Seismic behaviour of mountain belts controlled by plate convergence rate

Luca Dal Zilio [a], Ylona van Dinther [b], Taras V. Gerya [a], Casper C. Pranger [a]

Show more

See work of Ylona van Dinther and former students/postdocs (e.g., Luca Dal Zilio, Silvia Brizzi, Iris van Zelst)



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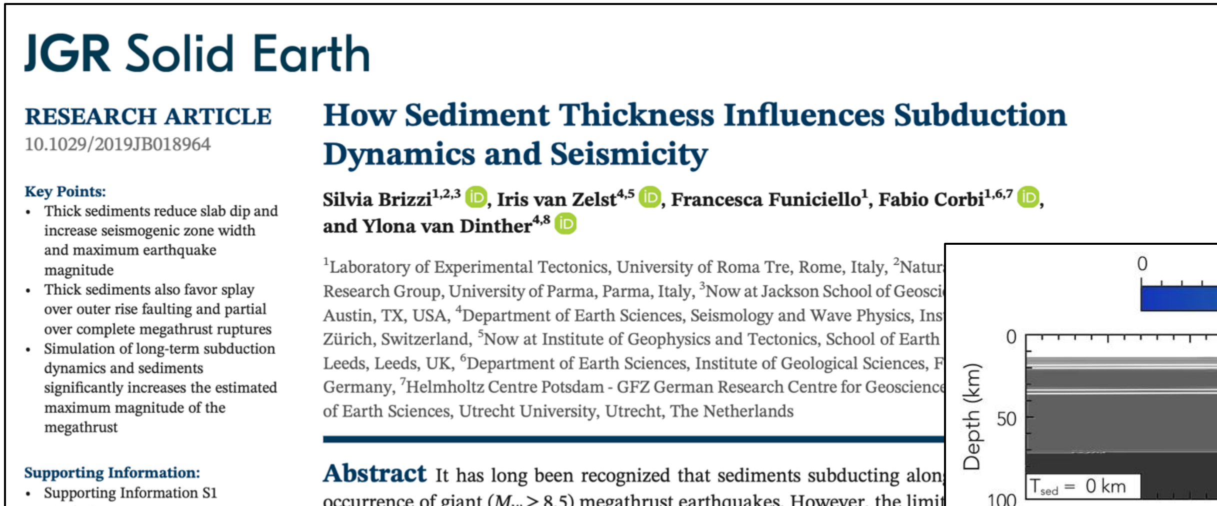
JGR Solid Earth

RESEARCH ARTICLE
10.1029/2019JB018964

How Sediment Thickness Influences Subduction Dynamics and Seismicity

Silvia Brizzi[1,2,3], Iris van Zelst[4,5], Francesca Funiciello[1], Fabio Corbi[1,6,7], and Ylona van Dinther[4,8]

[1]Laboratory of Experimental Tectonics, University of Roma Tre, Rome, Italy, [2]Natur... Research Group, University of Parma, Parma, Italy, [3]Now at Jackson School of Geosci... Austin, TX, USA, [4]Department of Earth Sciences, Seismology and Wave Physics, Ins... Zürich, Switzerland, [5]Now at Institute of Geophysics and Tectonics, School of Earth ... Leeds, Leeds, UK, [6]Department of Earth Sciences, Institute of Geological Sciences, F... Germany, [7]Helmholtz Centre Potsdam - GFZ German Research Centre for Geoscience... of Earth Sciences, Utrecht University, Utrecht, The Netherlands

Key Points:
- Thick sediments reduce slab dip and increase seismogenic zone width and maximum earthquake magnitude
- Thick sediments also favor splay over outer rise faulting and partial over complete megathrust ruptures
- Simulation of long-term subduction dynamics and sediments significantly increases the estimated maximum magnitude of the megathrust

Supporting Information:
- Supporting Information S1

Abstract It has long been recognized that sediments subducting alon... occurrence of giant (M_w > 8.5) megathrust earthquakes. However, the limit...

See work of Ylona van Dinther and former students/postdocs (e.g., Luca Dal Zilio, Silvia Brizzi, Iris van Zelst)