Trench retreat rates in narrow subduction zones controlled by overriding plate thickness

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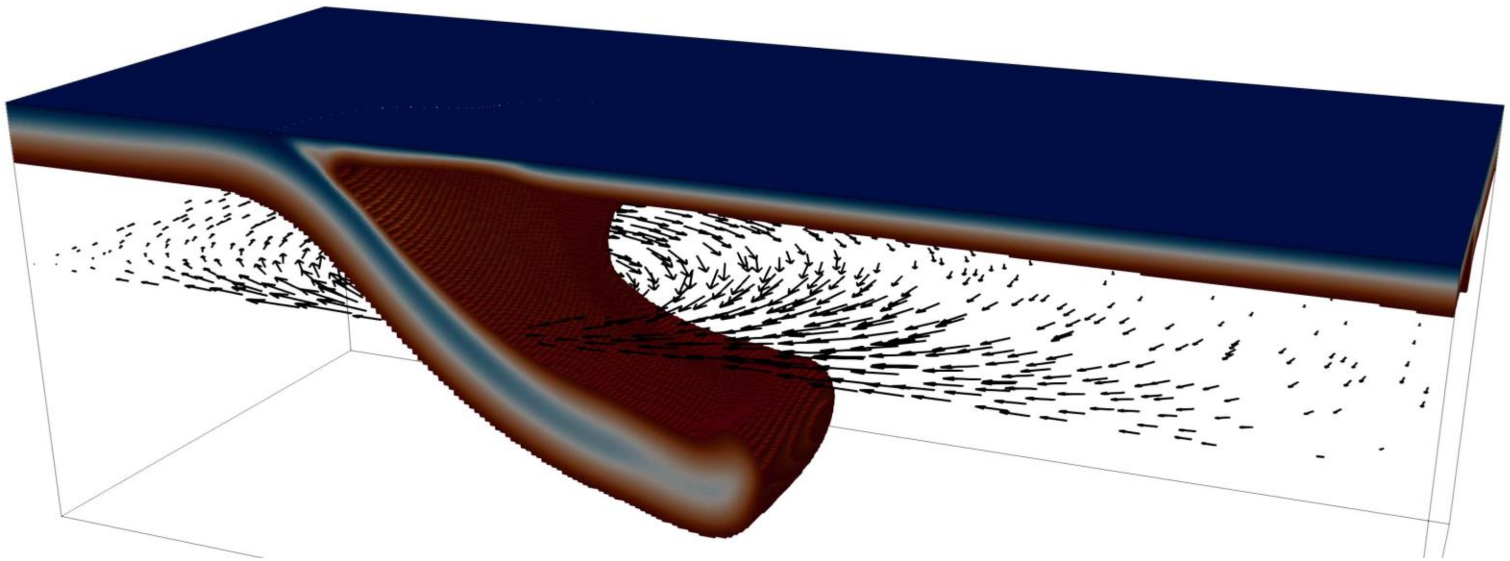

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1. Introduction

- Previous modelling works have studied the influence of slab width (W) on trench retreat velocities (V_T) (Schellart et al., 2007; Stegman et al., 2010), showing an inverse dependence of V_T on W: the wider the slab, the smaller the retreat velocity. However, when it comes to narrow subduction zones, there is no correlation between W and V_T.

- These studies that specifically focused on W did not include an overriding plate (OP), which is known to strongly affect subduction dynamics (Hertgen et al., 2020; Yamato et al., 2009).

What is happening with narrow subduction zones?

We have conducted 3D subduction models including an OP to evaluate the effect of W and OP thickness on V_T.

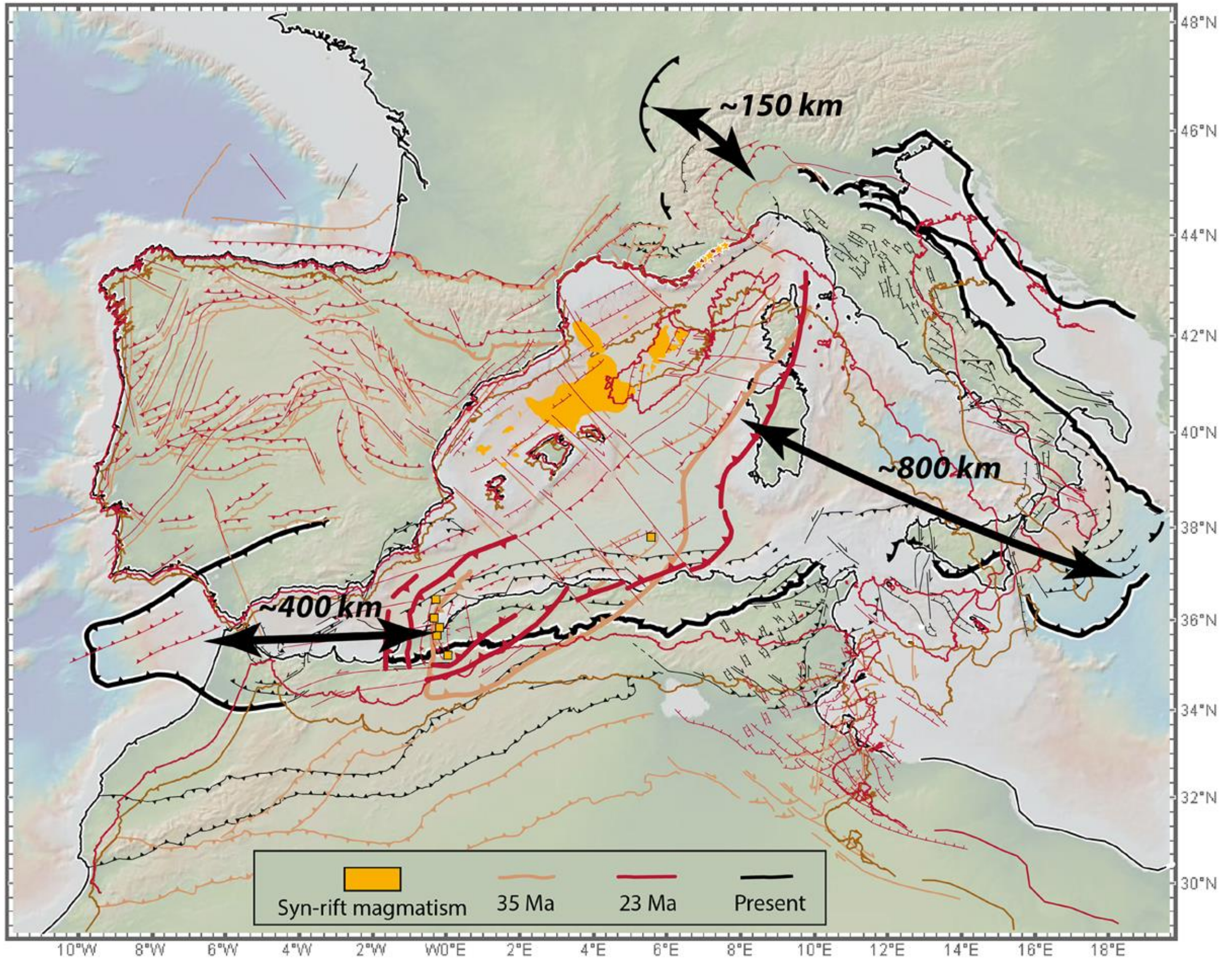
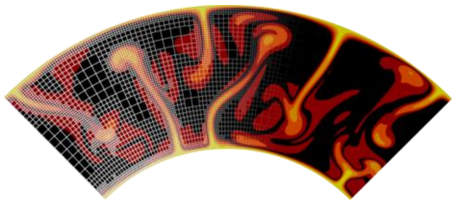


Figure 1. Synthetic overview of the displacements of the western Mediterranean subduction zones since 35 Ma. Figure taken from Romagny et al. (2020).

2. Methods

- Computations were done using the ASPECT code version 2.4.0. (Kronbichler et al., 2012; Heister et al., 2017; Bangerth et al., 2021a, 2021b).
- Boussinesq approximation and temperature-dependent viscosity.



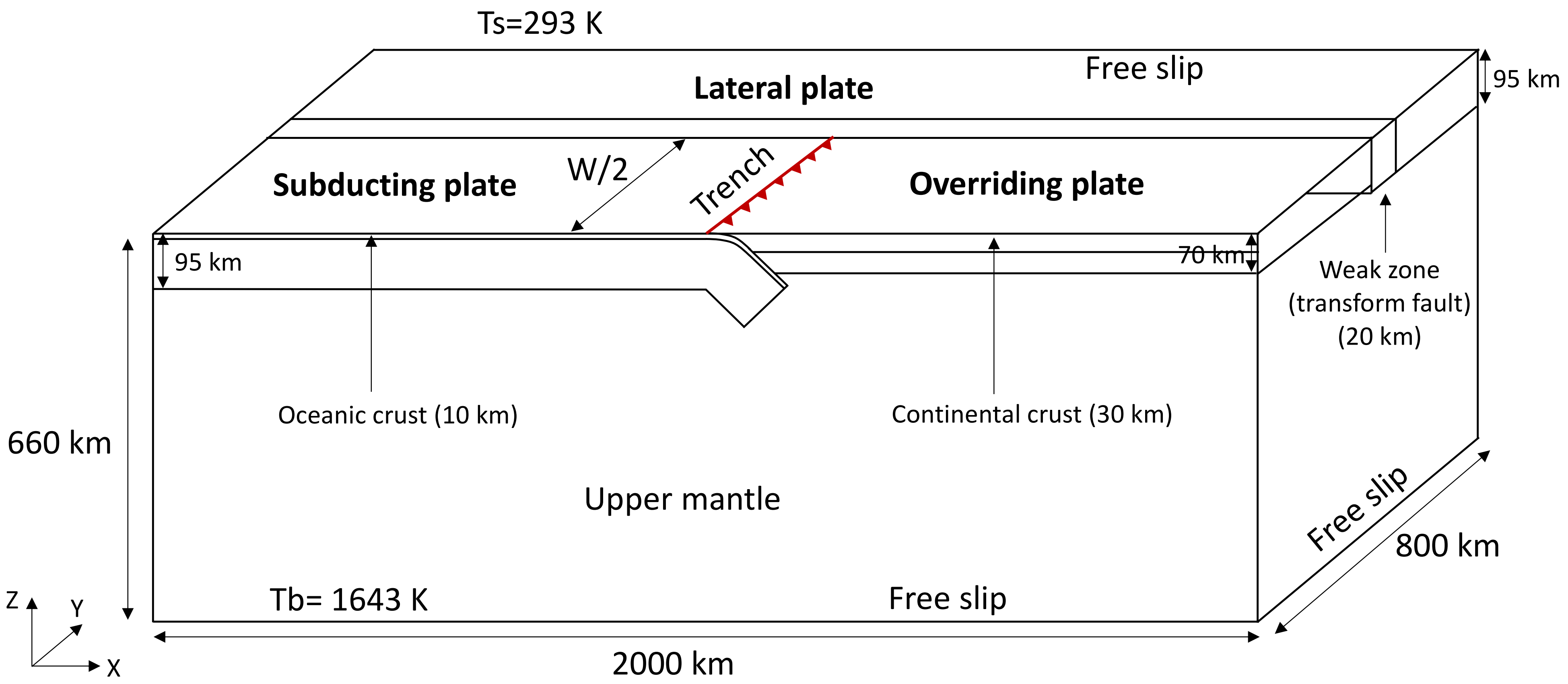


Figure 2. Three-dimensional model setup and boundary conditions. Only half of the subduction zone is modelled due to the symmetry of the problem.

3. Results

Trench retreat velocities

Effect of slab width: the effect of W on V_T is weak. V_T hardly varies more than 1 cm/yr when varying W between 400 and 1000 km.

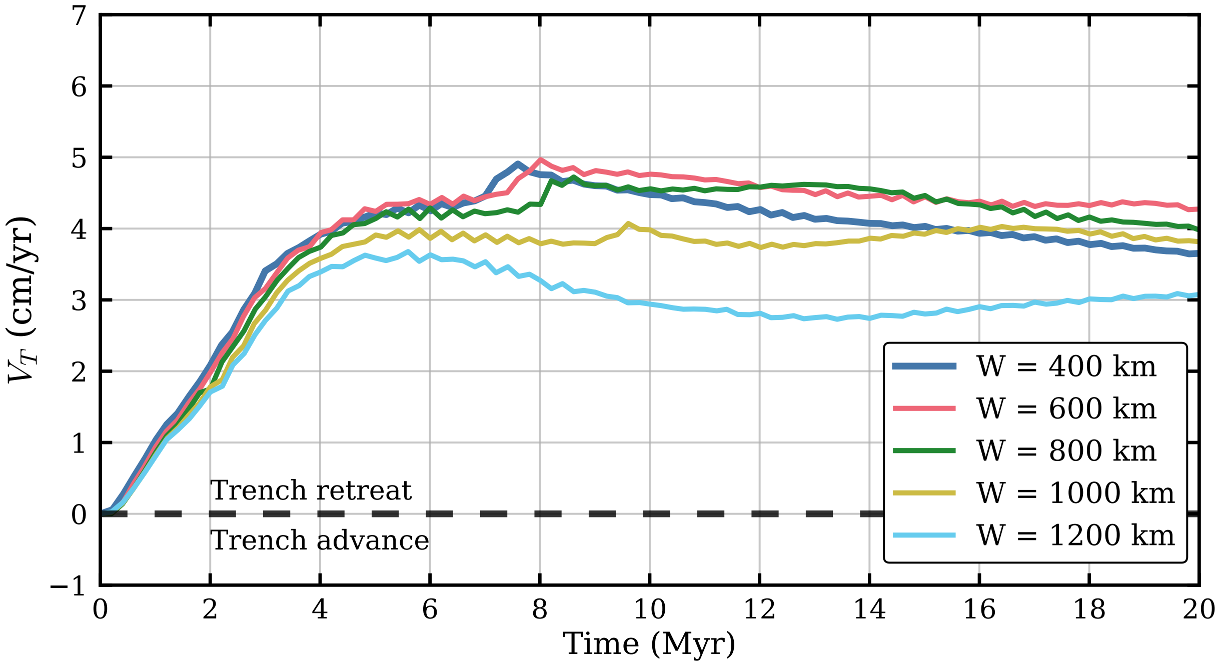


Figure 3. Trench retreat velocity over time (measured in the center of the subduction zone) for simulations with different slab width.

3. Results

Trench retreat velocities

Effect of slab width: the effect of W on V_T is weak. V_T hardly varies more than 1 cm/yr when varying W between 400 and 1000 km.

Effect of overriding plate thickness: Significant V_T decrease when increasing the OP thickness.

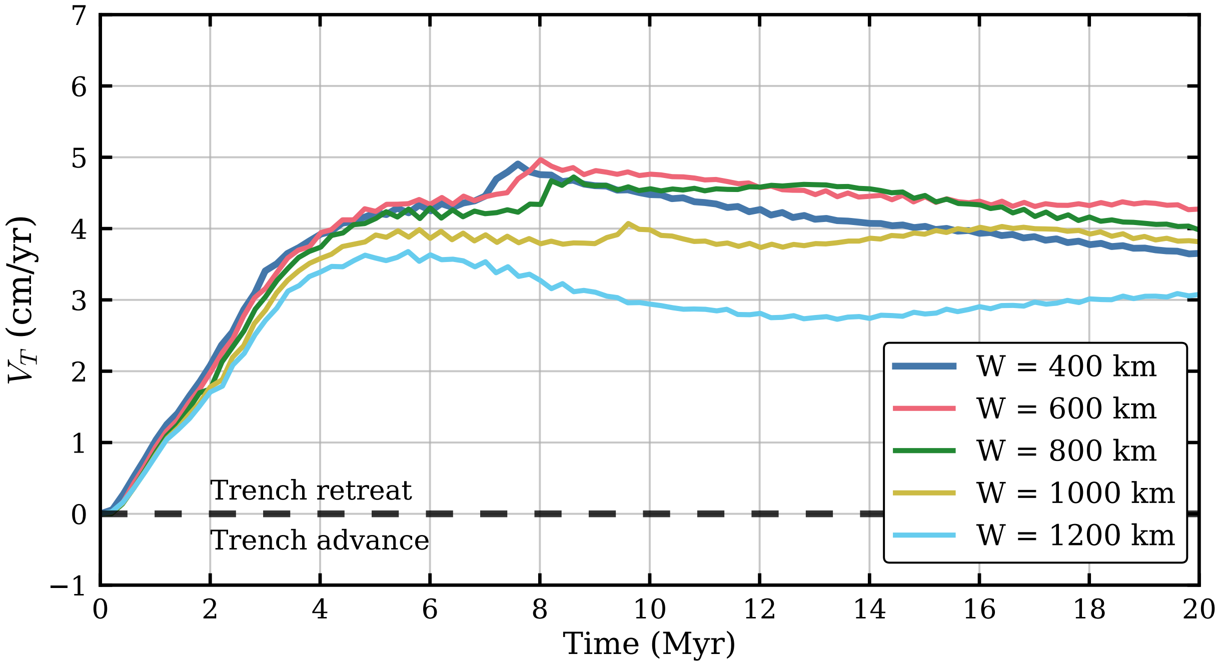


Figure 3. Trench retreat velocity over time (measured in the center of the subduction zone) for simulations with different slab width.

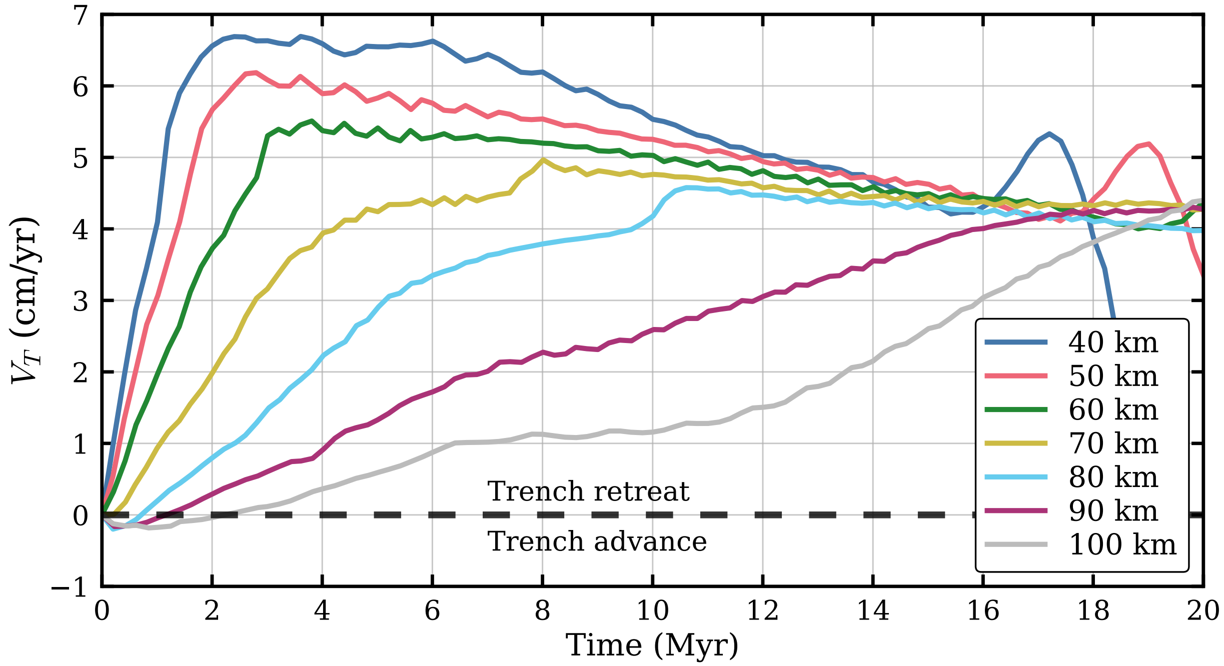


Figure 4. Trench retreat velocity over time (measured in the center of the subduction zone) for simulations with different overriding plate thickness.

3. Results

Trench retreat velocities observed in nature: Observations show a lack of correlation between W and V_T but an inverse dependence of V_T on OP thickness.

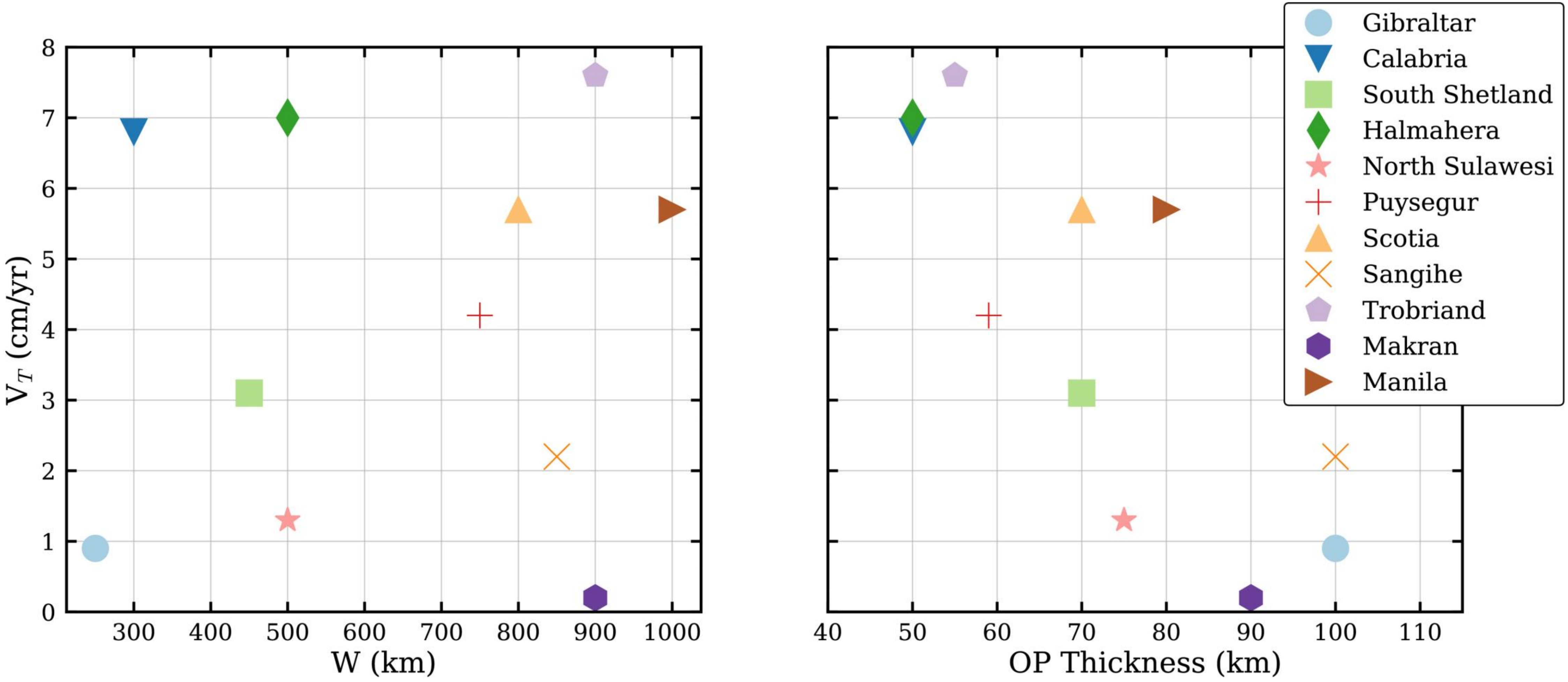


Figure 5. Trench retreat velocity against W and OP thickness for all subduction zones in Earth with W ≤ 1000 km.

3. Results

Trench geometry

- Models develop two types of trench geometries in the center of the subduction zone depending on W: concave for W ≤ 1000 km and "w"-shaped for W = 1200 km .

- Our model with W = 1200 km develops a "w"-shape for much smaller W than any of the previous studies not using an OP (e.g., Chen et al., 2022; Schellart et al., 2007; Stegman et al., 2010; Strak & Schellart, 2016).

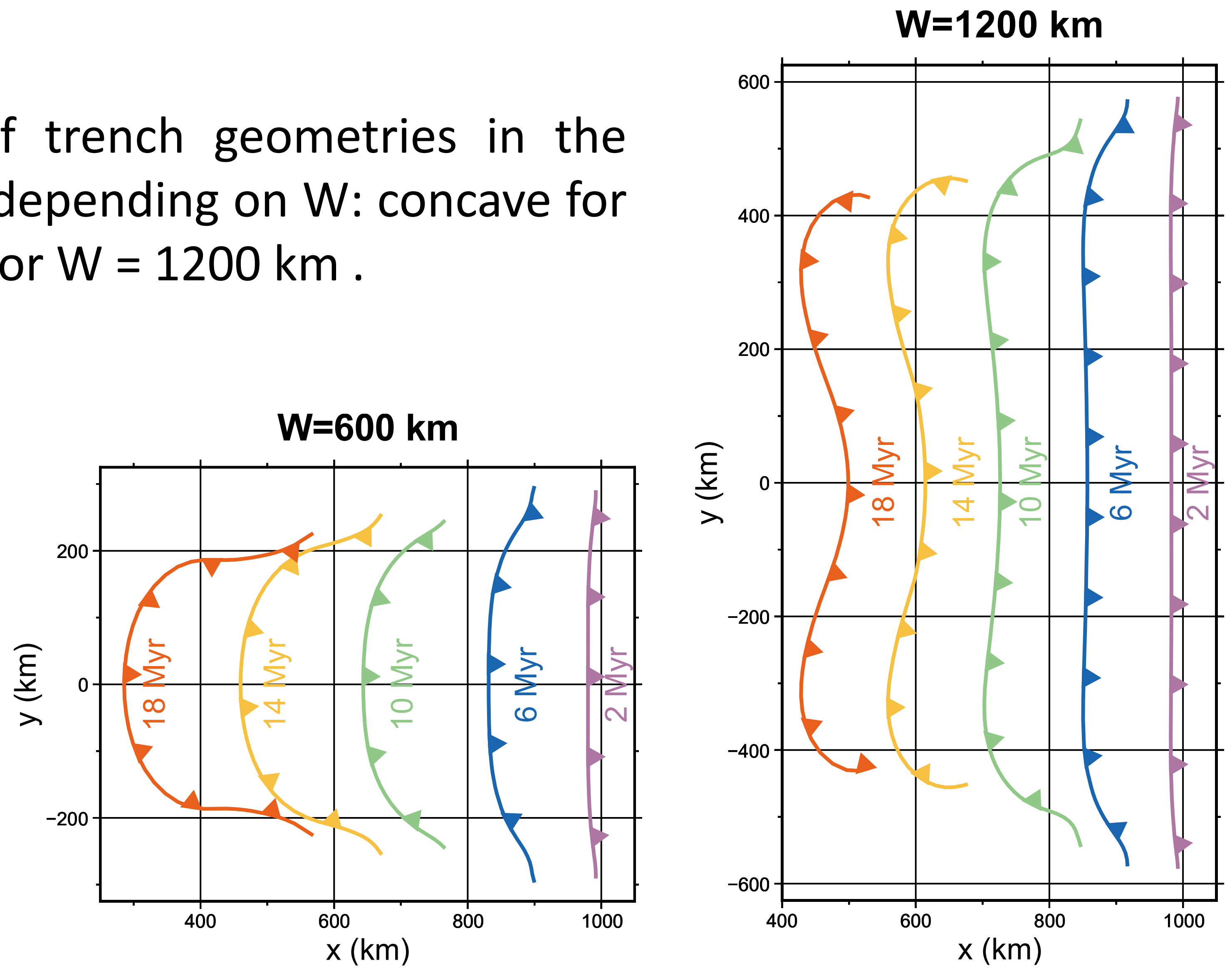


Figure 6. Evolution of the trench for simulations with W = 600 km and W =1200 km.

3. Results

Trench geometries observed in nature

- Our models explain trench geometries of natural subduction zones of narrow to intermediate widths.

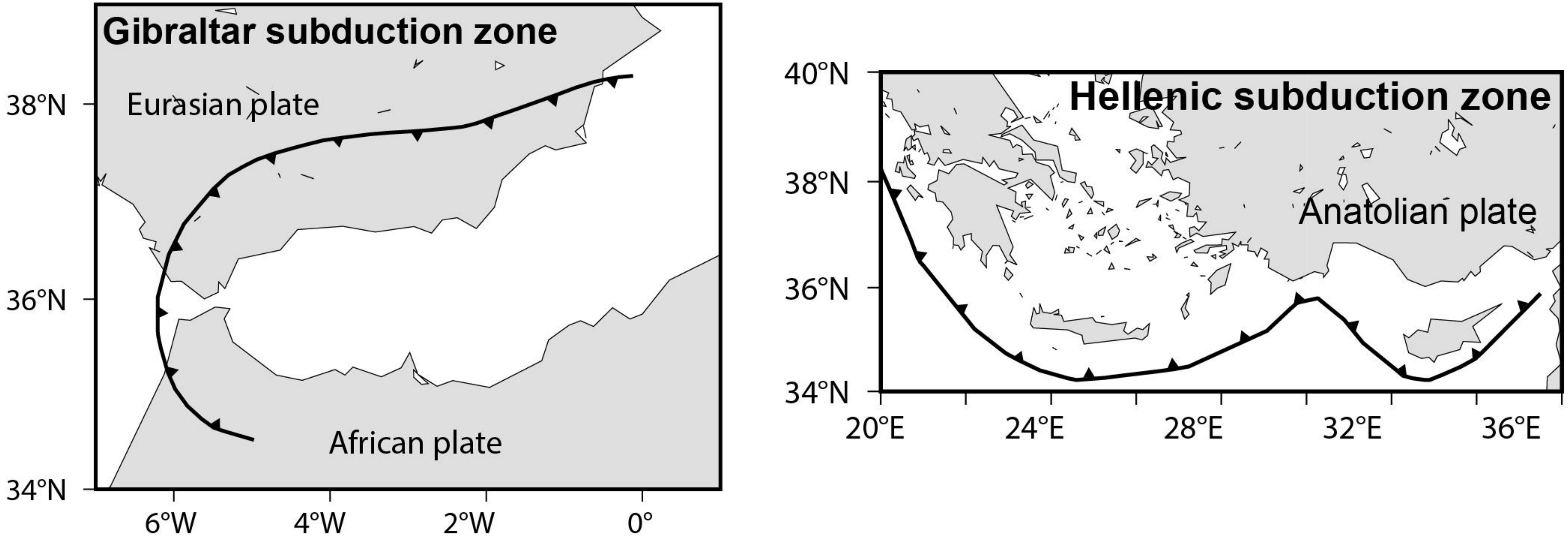


Figure 7. Subduction fronts at present-day for the Gibraltar subduction system and the Hellenic subduction zone.

4. Take-home message

1. The **slab width** has little effect on trench retreat velocities for narrow subduction zones.

2. The **overriding plate thickness** is the main controlling factor on trench retreat velocities for narrow subduction zones, with velocities decreasing as the thickness increases.

3. **Surrounding plates** significantly affect trench kinematics.

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Open to new ideas and collaborations, contact me at pedrog@ugr.es

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