AGU PUBLICATIONS

Tectonics

Supporting Information for

Caribbean plate boundaries control on the tectonic duality in the back-arc of the Lesser Antilles subduction zone during the Eocene

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Text S1 : Governing equations of the model

The governing equations of the subduction mechanical models are as follows. The physical domain $\Omega_t \subset \mathbb{R}^3$ occupied by the solid lithospheric plates at time t are given by the conservation of momentum and the rheological law for a Maxwell viscoelastic body:

$$\begin{cases} \operatorname{div} \boldsymbol{\sigma} + \rho\, \boldsymbol{g} = \mathbf{0} & \text{in } \Omega_t, \\ \dfrac{D\boldsymbol{\sigma}}{Dt} = 2\mu\dot{\boldsymbol{\epsilon}} + \lambda \operatorname{tr}(\dot{\boldsymbol{\epsilon}})\boldsymbol{I} + \dfrac{\mu}{\eta_l} \operatorname{dev} \boldsymbol{\sigma} & \text{in } \Omega_t, \end{cases} \quad (1)$$

where σ is the Cauchy stress field, ρ is the lithosphere density, $\boldsymbol{g}$ is the vector of gravity acceleration, and $\dot{\boldsymbol{\epsilon}} = \frac{1}{2}(\nabla \boldsymbol{v} + \nabla^T \boldsymbol{v})$ is the Eulerian strain-rate tensor given by the symmetric gradient of the velocity field $\boldsymbol{v}$. The operator $D\,\cdot / Dt$ represents an objective time derivative. $\boldsymbol{I}$ is the identity tensor. tr and dev are the trace and deviatoric operators. η_l is the viscosity of the plates, and λ and μ are the Lamé parameters:

$$\lambda = \frac{E\nu}{(1+\nu)(1-2\nu)}\,, \mu = \frac{E}{2(1+\nu)} \quad (2)$$

with E and ν the Young's modulus and the Poisson's ratio, respectively.

The plate-plate mechanical contact on the interface Γ_c is modeled with the Sigorini relation (no interpenetration, no attraction and complementary condition) and the Coulomb friction law:

$$\begin{cases} \delta v_n \leq 0\,, \quad \sigma_n \leq 0\,, \quad \delta v \sigma_n = 0 \text{ on } \Gamma_c, \\ |\sigma_t| \leq -\mu\sigma_n \text{ if } \delta v_t = 0 \text{ on } \Gamma_c, \\ \sigma_t = \mu\sigma_t \dfrac{\delta v_t}{|\delta v_t|} \text{ if } \delta v_t \neq 0 \text{ on } \Gamma_c, \end{cases} \quad (3)$$

where δv_n and δv_t are the outward normal and tangential components, respectively, of the relative velocity between two points in contact, and μ is the effective Coulomb friction coefficient. σ_n and σ_t are the normal and tangential stresses at the point of contact.

The lithospheric plate interfaces in contact with the inviscid mantle are subjected to the lithostatic pressure:

$$p_{litho} = \frac{1}{\beta}\ln(1 - \beta\rho_m^0 g z) \qquad (4)$$

where β is the compressibility modulus of the mantle, assumed to be constant, ρ_m^0 is the density at the base of the lithospheric plates, z is the depth and $g = |\boldsymbol{g}|$ is the gravity acceleration. See Hassani et al., (1997) for further details.

We use the finite element code ADELI (Hassani et al., 1997) to compute an approximate solution of the equations (1)-(3).

Figure S1: Strain field at the surface of the overriding plate and velocity profiles in the reference model

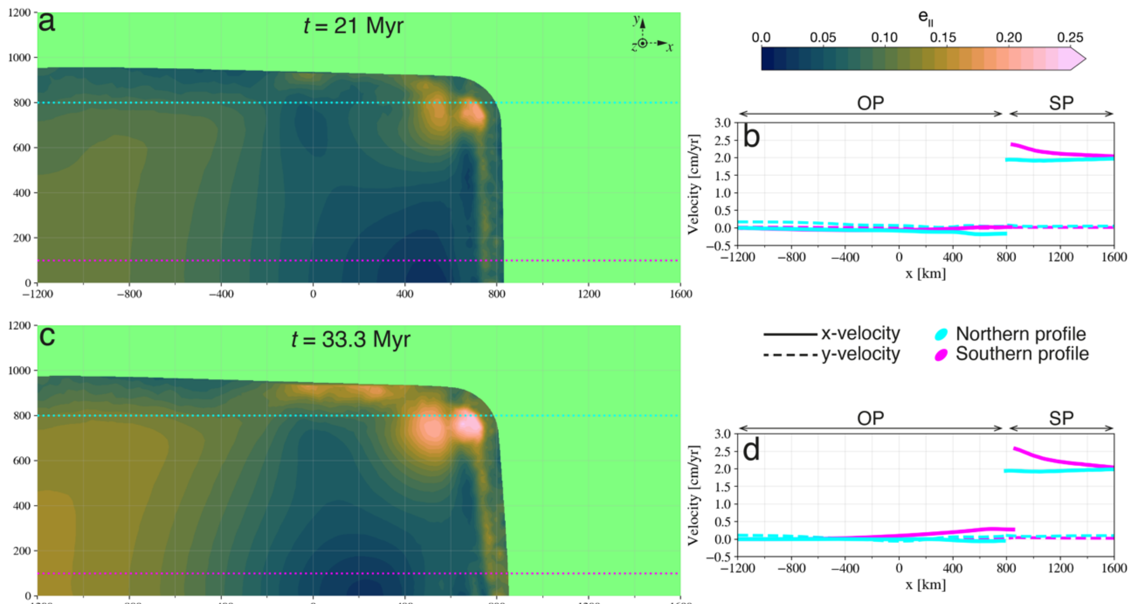

Figure S1: Snapshots of the evolution of the second invariant of the in-plane deviatoric strain e_{II} at the surface of the overriding plate (left) and profiles of in-plane velocity across both the overriding and the subducting plates (right) in the reference model. The velocities are positive trenchward.

Figure S2 Strain field at the surface of the overriding plate and velocity profiles in the model with a weak overriding plate

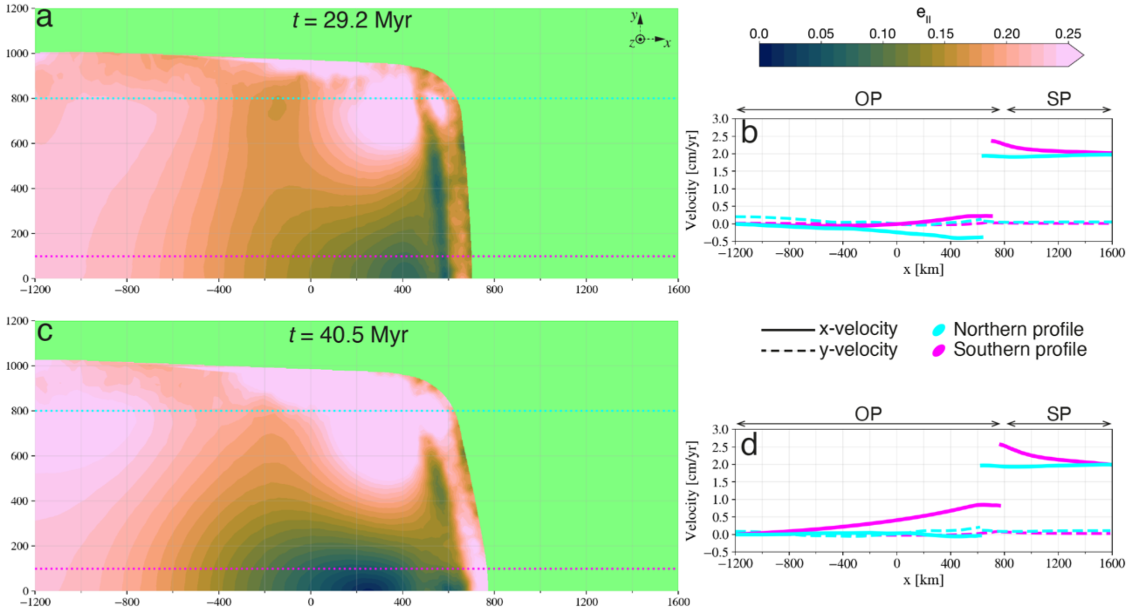

Figure S2: Snapshots of the evolution of the second invariant of the in-plane deviatoric strain e_{II} *at the surface of the overriding plate (left) and in-plane velocity profiles across both the overriding and the subducting plates (right) in the model with a weak overriding plate* (*viscosity of* 3×10^{23} Pa s). *The velocities are positive trenchward.*

References

Hassani, R., Jongmans, D., & Chéry, J. (1997). Study of plate deformation and stress in subduction processes using two-dimensional numerical models. *Journal of Geophysical Research: Solid Earth*, *102*(B8), 17951-17965.