Supplementary material for the paper "Can subduction initiation at a transform fault be spontaneous?"

by Diane Arcay, Serge Lallemand, Sarah Abecassis, Fanny Garel.

Geosciences Montpellier, Univ. Montpellier, CNRS, Univ. Antilles, Montpellier, France

The supplementary material contains:

- Additional data (Sect. S1): the whole simulation list (Table S1) and the graph illustrating the relationship between the brittle parameter, γ, in eq. 1 and the coefficient of internal friction (f_s, Fig. S1),
- the estimate of plate bending length L_0 when the oceanic crust is assumed to be weakened, and the regime diagram of plate deformation as a function of the weakening extent L_w (Sect. S2, Fig. S2 and S3),
- the results of extra experiments performed to precise the condition of OPS triggering (Sect. S3),
- how the different modes of OPS initiation are related to the YP age and thickness (Sect. S4, Fig. S4 and S5).

S1 Additionnal data

Table S1: Complete simulation list. *(continued on next pages)*

Run	A_y vs A_o (Myr, Myr)	γ_{TF}/γ_c or γ_c (if ②=③)[a]	γ_m	ρ_c/ρ_{TF}[b] (kg.m^{-3})	E_a[c] (kJ/mol)	L_w[c] ($A_y; A_o$) (km; km)	Specific test	Bottom B.C.	Result
S1a	0vs2	0.0005	1.6	3300	360	1100	-	open	OPS-mode 2
S1b	0vs2	0.05	1.6	3300	360	0	-	open	YPVSI
S1c	0vs2	0.05	1.6	3300	185	0	-	open	YP dripping
S2a	0vs5	0.0005	1.6	3300	360	1100	-	open	OPS-mode 2
S2b	0vs5	0.0005	0.05	3300	360	1100	-	open	OPS-mode 2
S2c	0vs5	0.0005/0.05	1.6	3300	360	50	-	closed	OPS-mode 2
S2d	0vs5	0.05	1.6	3300	360	0	-	open	YPVSI
S2e	0vs5	0.05	1.6	3300	185	0	-	open	YP dripping
S2f	0vs5	0.0005/0.05	1.6	2920/2920	360	TF only [d]	-	closed	cooling
S3a	0vs10	0.0005	1.6	3300	360	1100	-	open	OPS-mode 1
S3b	0vs10	0.0005	0.05	3300	360	1100	-	open	OPS-mode 1
S3c	0vs10	0.05	1.6	3300	360	0	-	open	YPVSI
S3d	0vs10	0.05	1.6	3300	185	0	-	open	YP dripping
S4a	0vs15	0.0005	1.6	3300	360	1100	-	open	OPS-mode 1
S4b	0vs15	0.0005	0.05	3300	360	1100	-	open	OPS-mode 1
S4c	0vs15	0.05	1.6	3300	360	0	-	open	YPVSI
S4d	0vs15	0.05	1.6	3300	185	0	-	open	YP dripping
S5a	0vs20	0.0005	1.6	3300	360	1100	-	open	OPS-mode 1
S5b	0vs20	0.0005/0.05	1.6	3300	360	50	-	closed	OPS-mode 1
S5c	0vs20	0.05	1.6	3300	360	0	-	open	YPVSI
S5d	0vs20	0.05	1.6	3300	185	0	-	open	YP dripping
S6a	0vs30	0.0005	1.6	3300	360	1100	-	open	OPS-mode 1
S6b	0vs30	0.05	1.6	3300	185	0	-	open	YP dripping
S7a	0vs40	0.0005	1.6	3300	360	1100	-	open	OPS-mode 1

continued on the next page...

. . . continued

Run	A_y,A_o	γ_{TF}/γ_c	γ_m	ρ_c/ρ_{TF}	E_a^c	L_w $(A_y;A_o)$	Test	Bottom BC	Result
S7b	0vs40	0.0005	0.05	3300	360	1100	-	open	OPS-mode 1
S7c	0vs40	0.0005/0.05	1.6	3300	360	TF only [d]	-	closed	cooling
S7d	0vs40	0.0005/0.05	1.6	3300	360	50	-	closed	YPVSI
S7e	0vs40	0.05	1.6	3300	360	0	-	open	YPVSI
S7f	0vs40	0.05	1.6	3300	185	0	-	open	YP dripping
S8a	0vs50	0.0005	1.6	3300	360	1100	-	open	OPS-mode 1
S8b	0vs50	0.05	1.6	3300	360	0	-	open	YPVSI
S9a	0vs60	0.0005	1.6	3300	360	1100	-	open	OPS-mode 1
S9b	0vs60	0.0005/0.05	1.6	3300	360	50	-	closed	YPVSI
S10a	0vs80	0.0005	1.6	3300	360	1100	-	open	OPS-mode 1
S10b	0vs80	0.0005/0.05	1.6	3300	360	TF only [d]	-	closed	cooling
S10c	0vs80	0.05	1.6	3300	360	0	-	open	YPVSI
S10d	0vs80	0.0005/0.05	1.6	3300	360	50	-	closed	YPVSI
S11a	0vs100	0.0005	1.6	3300	360	1100	-	open	OPS-mode 1
S11b	0vs100	0.0005/0.05	1.6	3300	360	TF only [d]	-	closed	cooling
S11c	0vs100	0.05	1.6	3300	360	0	-	open	cooling
S12a	0vs120	0.0005/0.05	1.6	3300	360	TF only [d]	-	closed	cooling
S12b	0vs120	0.0005	1.6	3300	360	-	-	closed	OPS-mode 1
S13b	0vs130	0.05	1.6	3300	360	0	-	open	cooling
S14a	2vs5	0.05	1.6	3300	360	0	-	open	cooling
S14b	2vs5	0.05	1.6	3300	360	0	-	open	cooling
S14c	2vs5	0.0005	1.6	3300	360	1100	-	open	OPS-mode 2, SB
S14d	2vs5	0.0005	1.6	3300	360	1100	tw=11km	open	OPS-mode 2, SB
S14e	2vs5	0.05	1.6	3300	185	0	-	open	OPS-mode 2, SB
S14f	2vs5	0.0005	1.6	3300	360	1100;0	-	open	YPS
S14g	2vs5	0.0005	1.6	3300	360	TF only [d]	-	open	cooling
S14h	2vs5	0.05	1.6	3300	360	0	ΔT_p =250^{o}C	open	YP dripping
S14i	2vs5	0.0005	1.6	3300	360	17;42	-	open	OPS-mode 2
S14j	2vs5	0.0005	1.6	3300	360	8.5;20	-	open	OPS-mode 2
S14k	2vs5	0.0005	1.6	3300	360	4.3;10	-	open	OPS-mode 2
S14l	2vs5	0.0005	1.6	3300	360	2.2;5	-	open	Close to OPS
S14m	2vs5	0.0005/0.05	1.6	3300	360	50	-	closed	OPS-mode 2
S14n	2vs5	0.0005/0.05	1.6	2920/3300	360	50	-	closed	Double SI
S14o	2vs5	0.0005/0.05	1.6	2920/2920	360	TF only [d]	-	closed	cooling
S14p	2vs5	0.0005/0.05	1.6	2920/3300	360	TF only [d]	-	closed	cooling
S14q	2vs5	0.0005/0.01	0.8	3160/3160	360	50	-	closed	Close to OPS
S14r	2vs5	0.0005/0.01	0.8	3160/3300	360	50	-	closed	OPS
S14s	2vs5	0.05/0.0005	1.6	3300	360	TF only [d]	-	closed	YPS then OPS
S15a	2vs10	0.05	1.6	3300	185	0	-	open	YP dripping
S14t	2vs5	0.0005/0.01	0.8	3160/3160	360	50	-	closed	Close to OPS
S15b	2vs10	0.0005	1.6	3300	360	1100	-	open	OPS-mode 2
S15c	2vs10	0.0005/0.05	1.6	3300	360	1100	-	closed	Close to OPS
S15d	2vs10	0.0005	1.6	3300	360	0;1100	-	open	cooling
S15e	2vs10	0.0005	1.6	3300	360	1100;0	-	open	cooling
S15f	2vs10	0.0005/0.05	1.6	3300	360	TF only [d]	-	closed	YPVSI
S15g	2vs10	0.05	1.6	2920/3300	185	1100	-	closed	YPVSI
S15h	2vs10	0.05	1.6	2920/3300	360	1100	ΔT_p =250^{o}C	open	YPSI
S15i	2vs10	0.0005/0.01	0.8	3160/3160	360	50	-	closed	Close to OPS
S15j	2vs10	0.0005/0.01	0.8	3160/3300	360	50	-	closed	OPS-mode 2

continued on the next page. . .

. . . continued

Run	A_y,A_o	γ_{TF}/γ_c	γ_m	ρ_c/ρ_{TF}	E_a^c	L_w ($A_y;A_o$)	Test	Bottom BC	Result
S15k	2vs10	0.0005/0.01	0.8	3160/3160	360	50	-	closed	Close to OPS
S16a	2v20	0.0005/0.05	1.6	3300	360	50	-	closed	Close to OPS
S16b	2v20	0.0005/0.05	1.6	2920/3300	360	50	-	closed	Heavy YPS
S16c	2v20	0.0005/0.05	1.6	2920/2920	360	TF only [d]	-	closed	YP retreat
S16d	2v20	0.0005/0.05	1.6	2920/3300	360	50	-	closed	Heavy YPS
S16e	2vs20	0.05	1.6	3300	360	0	-	open	cooling
S16f	2vs20	0.0005/0.01	0.6	3160/3160	360	50	-	closed	OPS-mode 2
S16g	2vs20	0.05/0.05	1.6	2920/3330	360	50	-	closed	YP shortening
S16hw	2vs20	0.0005/0.01	0.8	3160/3160	360	50	-	closed	OPS-mode 2
S17a	2vs40	0.05	1.6	3300	360	0	-	open	cooling
S17b	2vs40	0.05	1.6	3300	360	0	-	open	YPVSI
S17c	2vs40	0.0005	1.6	3300	360	1100	-	open	OPS-mode 2
S17d	2vs40	0.05	1.6	3300	185	0	-	open	YP dripping
S17e	2vs40	0.0005	1.6	3300	360	1100	-	open	OPS-mode 1
S17f	2vs40	0.05	1.6	3300	185	0	-	open	YP dripping
S17g	2vs40	0.0005	1.6	3300	360	0;1100	-	open	Close to OPS
S17h	2vs40	0.0005	1.6	3300	360	1100;0	-	open	YPVSI
S17i	2vs40	0.0005	1.6	3300	360	TF only [d]	-	open	cooling
S17j	2vs40	0.05	1.6	3300	360	0	ΔT_p =250^{o}C	open	YP drippping
S17k	2vs40	0.0005/0.05	1.6	3300	360	TF only [d]	-	closed	cooling
S17l	2vs40	0.0005/0.05	1.6	3300	360	1100	-	closed	cooling
S17m	2vs40	0.0005	1.6	2920/3300	360	TF only [d]	-	closed	Close to OPS
S17n	2vs40	0.0005	1.6	3300	360	TF only [d]	-	closed	OPS-mode 2
S17o	2vs40	0.0005/0.05	1.6	3300	360	50	-	closed	YPVSI.
S17p	2vs40	0.0005/0.05	1.6	2920/2920	360	TF only [d]	-	closed	YP retreat
S17q	2vs40	0.0005/0.05	1.6	2920/3300	360	TF only [d]	-	closed	YPVSI
S17r	2vs40	0.0005/0.05	1.6	2920/3300	360	50	-	closed	YPVSI
S17s	2vs40	0.0005/0.05	1.6	3300	360	TF only [d]	-	closed	YPVSI
S17t	2vs40	0.0005/0.01	0.6	3160/3160	360	50	-	closed	OPS-mode 2
S17u	2vs40	0.05/0.0005	1.6	3300	360	TF only [d]	-	closed	YPS
S17w	2vs40	0.0005/0.01	0.8	3160/3160	360	50	-	closed	OPS-mode 2
S18a	2vs80	0.05	1.6	3300	360	0	-	open	YPVSI
S18a2	2vs80	0.05	1.6	3300	360	0	tw=11km	open	YPVSI
S18b	2vs80	0.0005	1.6	3300	360	1100	-	open	OPS-mode 2
S18b2	2vs80	0.0005	1.6	3300	360	1100	tw=11km	open	OPS-mode 2
S18b3	2vs80	0.0005	1.6	3300	360	1100	tw=30 km	open	OPS-mode 2
S18b4	2vs80	0.0005	1.6	3300	360	1100	tw=50 km	open	OPS-mode 2
S18b5	2vs80	0.0005	1.6	3300	360	1100	tw=70 km	open	OPS-mode 2
S18c	2vs80	0.005	1.6	3300	360	1100	-	open	cooling
S18d	2vs80	0.0007	1.6	3300	360	1100	-	open	OPS-mode 2
S18e	2vs80	0.001	1.6	3300	360	1100	-	open	OPS-mode 2
S18f	2vs80	0.05	1.6	3300	185	0	-	open	YP dripping
S18g	2vs80	0.05	1.6	3300	185	0	-	open	YP dripping
S18h	2vs80	0.0005	1.6	3300	360	0;1100	-	open	Close to OPS
S18i	2vs80	0.0005	1.6	3300	360	1100;0	-	open	YP dripping
S18j	2vs80	0.0005	1.6	3300	360	TF only [d]	-	open	cooling
S18k	2vs80	0.05	1.6	3300	360	0	ΔT_p =250^{o}C	open	YP dripping
S18l	2vs80	0.0005	1.6	3300	360	1100	-	closed	OPS-mode 2
S18m	2vs80	0.0005	1.6	2920/3300	360	TF only [d]	-	closed	Close to OPS

continued on the next page. . .

. . . continued

Run	A_y,A_o	γ_{TF}/γ_c	γ_m	ρ_c/ρ_{TF}	E_a^c	L_w (A_y; A_o)	Test	Bottom BC	Result
S18n	2vs80	0.0005/0.05	1.6	3300	360	TF only [d]	-	closed	cooling
S18o	2vs80	0.0005/0.05	0.6	3300	360	TF only [d]	-	closed	cooling
S18p	2vs80	0.0005	0.6	2920/3300	360	TF only [d]	-	closed	OPS-mode 2
S18q	2vs80	0.0005/0.05	1.6	3300	360	50	-	closed	YPVSI
S18r	2vs80	0.0005/0.05	1.6	2920/2920	360	TF only [d]	-	closed	YP retreat
S18s	2vs80	0.0005/0.05	1.6	2920/3300	360	TF only [d]	-	closed	YPVSI
S18t	2vs80	0.0005/0.05	1.6	3300	360	50	-	closed	YP retreat
S18u	2vs80	0.0005/0.05	1.6	3300	360	TF only [d]	-	closed	YPVSI
S19a	2vs100	0.05	1.6	3300	360	0	-	open	YPVSI
S19b	2vs100	0.0005	1.6	3300	360	0	-	open	OPS-mode 2
S20a	2vs120	0.0005	1.6	3300	360	0	-	open	OPS-mode 2
S21a	5vs10	0.0005	0.1	3300	360	1100	-	open	OPS-mode 1
S21b	5vs10	0.0005/0.05	1.6	2920/3300	360	50	-	closed	YPVSI
S21c	5vs10	0.0005/0.05	1.6	3300	360	50	-	closed	YPVSI
S21d	5vs10	0.0005/0.05	1.6	3300	360	TF only [d]	-	closed	cooling
S22a	5vs15	0.05	1.6	3300	360	0	-	open	cooling
S22b	5vs15	0.05	1.6	3300	360	0	-	open	cooling
S22c	5vs15	0.0005	1.6	3300	360	1100	-	open	cooling
S22d	5vs15	0.00005	1.6	3300	360	1100	-	open	cooling
S22e	5vs15	0.05	1.6	3300	185	0	-	open	cooling
S22f	5vs15	0.0005	1.6	3300	360	1100	-	open	cooling
S22g	5vs15	0.00005	1.6	3300	185	1100	-	open	cooling
S22h	5vs15	0.0005	1.6	3300	360	1100	$\nu_{ref}/5$	open	cooling
S22i	5vs15	0.0005	0.2	3300	360	1100	-	open	cooling
S22j	5vs15	0.0005	0.1	3300	360	1100	-	open	OPS-mode 2+SB
S22k	5vs15	0.0005	0.05	3300	360	1100	-	open	OPS-mode 2+SB
S22l	5vs15	0.05	1.6	3300	185	0	-	open	cooling
S22m	5vs15	0.00005	1.6	3300	185	1100	-	open	cooling
S22n	5vs15	0.0005	1.6	3300	360	0;1100	-	open	cooling
S22o	5vs15	0.00005	1.6	3300	360	0;1100	-	open	cooling
S22p	5vs15	0.0005	1.6	3300	360	1100;0	-	open	cooling
S22q	5vs15	0.00005	1.6	3300	360	1100;0	-	open	cooling
S22r	5vs15	0.0005	1.6	3300	360	TF only [d]	-	open	cooling
S22s	5vs15	0.05	1.6	3300	360	0	ΔT_p =250^{o}C	open	cooling
S22t	5vs15	0.00005	1.6	3300	360	1100	-	open	cooling
S23a	5vs20	0.0005	1.6	3300	360	1100	-	open	cooling
S23b	5vs20	0.05	1.6	3300	185	0	-	open	cooling
S23c	5vs20	0.0005/0.05	1.6	3300	360	50	-	closed	brief YPVSI
S23d	5vs20	0.0005/0.05	1.6	2920/3300	360	50	-	closed	YPVSI
S23e	5vs20	0.0005/0.05	1.6	2920/2920	360	TF only [d]	-	closed	YPS
S23f	5vs20	0.0005/0.05	1.6	2920/3300	360	TF only [d]	-	closed	YPVSI
S24a	5vs30	0.0005	1.6	3300	360	1100	-	open	Close to OPS
S24b	5vs30	0.05	1.6	3300	185	0	-	open	cooling
S25a	5vs35	0.0005	1.6	3300	360	1100	-	open	Close to OPS
S25b	5vs35	0.0005	1.6	3300	360	1100	E_a^m =390 kJ/mol	open	Close to OPS
S25c	5vs35	0.0005	1.6	3300	360	1100	E_a^m =360 kJ/mol	open	Close to OPS
S25d	5vs35	0.0005	1.6	3300	360	1100	E_a^m =300 kJ/mol	open	Close to OPS
S26a	5vs40	0.0005	1.6	3300	360	1100	-	open	OPS
S26b	5vs40	0.0005/0.05	1.6	3300	360	50	-	closed	brief YPVSI

continued on the next page. . .

...continued

Run	A_y,A_o	γ_{TF}/γ_c	γ_m	ρ_c/ρ_{TF}	E_a^c	L_w (A_y; A_o)	Test	Bottom BC	Result
S26c	5vs40	0.0005/0.05	1.6	2920/2920	360	TF only [d]	-	closed	YPS
S26d	5vs40	0.0005/0.05	0.05	2920/3300	360	50	-	closed	YPVSI
S26e	5vs40	0.0005/0.05	1.6	3300	360	TF only [d]	-	closed	cooling
S27a	5vs50	0.0005	1.6	3300	360	1100	-	open	OPS-mode 1
S27b	5vs50	0.05	1.6	3300	185	0	-	open	cooling
S27c	5vs50	0.0005	1.6	3300	360	42;260	-	open	OPS-mode 1
S27d	5vs50	0.0005	1.6	3300	360	20;142	-	open	Close to OPS
S27e	5vs50	0.0005	1.6	3300	360	10;71	-	open	cooling
S27f	5vs50	0.05	1.6	3300	360	0	-	open	cooling
S28a	5vs80	0.0005/0.05	1.6	3300	360	50	-	closed	YPVSI
S28b	5v80	0.0005/0.05	1.6	3300	360	50	-	closed	YPVSI
S28c	5v80	0.0005/0.05	1.6	2920/3300	360	50	-	closed	cooling
S28d	5v80	0.0005/0.05	1.6	2920/3300	360	TF only [d]	-	closed	YPVSI
S28e	5vs80	0.0005/0.05	1.6	2920/2920	360	TF only [d]	-	closed	YPS
S28f	5vs80	0.0005/0.05	1.6	3300	360	TF only [d]	-	closed	cooling
S29a	5vs100	0.0005	1.6	3300	360	0	-	open	OPS-mode 1
S29b	5vs120	0.0005	1.6	3300	360	0	-	open	Close to OPS
S30a	7vs20	0.0005	0.1	3300	360	1100	-	open	cooling
S30b	7vs20	0.0005	0.05	3300	360	1100	-	open	cooling
S31a	7vs30	0.0005	0.1	3300	360	1100	-	open	OPS-mode 1
S32a	7vs70	0.0005	1.6	3300	360	1100	-	open	cooling
S32b	7vs70	0.0005	1.6	3300	360	1100	E_a^m =390 kJ/mol	open	Close to OPS
S32c	7vs70	0.0005	1.6	3300	360	1100	E_a^m =360 kJ/mol	open	Close to OPS
S32d	7vs70	0.0005	1.6	3300	360	1100	E_a^m =300 kJ/mol	open	Close to OPS
S33a	7vs80	0.0005	1.6	3300	360	1100	-	open	Close to OPS
S33b	7vs80	0.0005	1.6	3300	360	1100	E_a^m =390 kJ/mol	open	Close to OPS
S33c	7vs80	0.0005	1.6	3300	360	1100	E_a^m =360 kJ/mol	open	Close to OPS
S33d	7vs80	0.0005	1.6	3300	360	1100	E_a^m =300 kJ/mol	open	Close to OPS
S34a	7vs90	0.0005	1.6	3300	360	1100	-	open	Close to OPS
S34b	7vs90	0.0005	0.1	3300	360	1100	-	open	OPS, SB
S34c	7vs90	0.0005	1.6	3300	360	1100	E_a^m =390 kJ/mol	open	Close to OPS
S34d	7vs90	0.0005	1.6	3300	360	1100	E_a^m =360 kJ/mol	open	Close to OPS
S34e	7vs90	0.0005	1.6	3300	360	1100	E_a^m =300 kJ/mol	open	OPS
S35a	7vs100	0.0005	1.6	3300	360	1100	-	open	OPS-mode 1
S35b	7vs120	0.0005	1.6	3300	360	1100	-	open	Close to OPS
S36a	10vs20	0.0005	0.05	3300	360	1100	-	open	cooling
S36b	10vs20	0.0005/0.05	1.6	2920/2920	360	TF only [d]	-	closed	YPs
S36c	10vs20	0.0005/0.05	1.6	2920/3300	360	50	-	closed	cooling
S37a	10vs40	0.05	1.6	3300	360	0	-	open	cooling
S37b	10vs40	0.0005	1.6	3300	360	1100	-	open	cooling
S37b2	10vs40	0.0005	1.6	3300	360	1100	$\nu_{ref}/10$	open	cooling
S37c	10vs40	0.0005	0.4	3300	360	1100	-	open	cooling
S37d	10vs40	0.0005	0.1	3300	360	1100	-	open	Close to OPS
S37e	10vs40	0.0005	0.075	3300	360	1100	-	open	Close to OPS
S37f	10vs40	0.0005	0.05	3300	360	1100	-	open	OPS-mode 1
S37g	10vs40	0.05	1.6	3300	185	1100	-	open	cooling
S37h	10vs40	0.0005	0.05	3300	360	0;1100	-	open	Close to OPS
S37i	10vs40	0.0005	0.05	3300	360	85;238	-	open	cooling
S37j	10vs40	0.0005	0.05	3300	360	43;119	-	open	cooling

continued on the next page...

. . . continued

Run	A_y,A_o	γ_{TF}/γ_c	γ_m	ρ_c/ρ_{TF}	E_a^c	L_w ($A_y;A_o$)	Test	Bottom BC	Result
S37k	10vs40	0.0005	0.05	3300	360	21;60	-	open	cooling
S37l	10vs40	0.0005/0.05	0.05	3300	360	50	-	closed	cooling
S37m	10vs40	0.05	1.6	3300	185	0	-	open	cooling
S37n	10vs40	0.0005	1.6	3300	360	0;1100	-	open	cooling
S37o	10vs40	0.0005	1.6	3300	360	1100;0	-	open	cooling
S37p	10vs40	0.0005	1.6	3300	360	TF only [d]	-	open	cooling
S37q	10vs40	0.05	1.6	3300	360	0	ΔT_p =250^{o}C	open	cooling
S37r	10vs40	0.0005	1.6	3300	360	1100	-	open	cooling
S37s	10vs40	0.00005	1.6	3300	360	1100	-	open	cooling
S37t	10vs40	0.00005	1.6	3300	360	1100	-	open	cooling
S37u	10vs40	0.00005	1.6	3300	360	1100	-	open	cooling
S37v	10vs40	0.05	1.6	3300	150	0	-	open	cooling
S37w	10vs40	0.0005/0.05	0.05	2920/2920	360	TF only [d]	-	closed	YPS
S37x	10vs40	0.0005/0.05	0.05	2920/3300	360	TF only [d]	-	closed	cooling
S37y	10vs40	0.0005/0.05	0.05	2920/3300	360	50	-	closed	cooling
S37z	10vs40	0.0005/0.05	1.6	3300	360	TF only [d]	-	closed	cooling
S38a	10vs50	0.0005	0.1	3300	360	1100	-	open	OPS-mode 1
S39a	10vs60	0.0005	1.6	3300	360	1100	-	open	cooling
S39b	10vs60	0.0005	0.1	3300	360	1100	-	open	OPS-mode 1
S40a	10vs80	0.0005	1.6	3300	360	1100	-	open	cooling
S40b	10vs80	0.0005/0.05	1.6	3300	360	50	-	closed	cooling
S40c	10vs80	0.0005/0.05	1.6	2920/2920	360	TF only [d]	-	closed	YPS
S41a	10vs100	0.0005	1.6	3300	360	1100	-	open	cooling
S42a	10vs130	0.0005	1.6	3300	360	1100	-	open	cooling
S42b	10vs130	0.0005	1.6	3300	360	1100	-	open	cooling
S43a	10vs140	0.0005	1.6	3300	360	1100	-	open	Close to OPS
S44a	10vs150	0.0005	1.6	3300	360	1100	-	open	Close to OPS
S45a	15vs30	0.0005	0.05	3300	360	1100	-	open	cooling
S46a	15vs40	0.0005	1.6	3300	360	1100	-	open	Close to OPS
S46b	15vs40	0.0005/0.05	1.6	2920/2920	360	TF only [d]	-	closed	YPS
S47a	15vs60	0.0005	0.1	3300	360	1100	-	open	OPS-mode 1
S47b	15vs60	0.0005	0.08	3300	360	1100	-	open	OPS-mode 1
S47c	15vs60	0.0005	0.06	3300	360	1100	-	open	OPS-mode 1
S47d	15vs60	0.0005	0.05	3300	360	1100	-	open	OPS-mode 1
S48a	15vs80	0.0005/0.05	1.6	2920/2920	360	TF only [d]	-	closed	YPS
S49a	20vs40	0.05	1.6	3300	360	0	-	open	cooling
S49b	20vs40	0.0005	1.6	3300	360	1100	-	open	cooling
S49c	20vs40	0.00005	1.6	3300	360	1100	-	open	cooling
S49d	20vs40	0.0005	1.6	3300	360	1100	-	open	cooling
S49e	20vs40	0.00005	1.6	3300	360	1100	-	open	cooling
S49f	20vs40	0.0005	1.6	3300	360	1100	$\nu_{ref}/10$	open	cooling
S49g	20vs40	0.0005	0.05	3300	360	1100	-	open	cooling
S49h	20vs40	0.0005	0.005	3300	360	1100	-	open	OPS, SB, YPD
S49i	20vs40	0.0005	0.005	3300	360	151;238	-	open	OPS, SB, YPD
S49j	20vs40	0.0005	0.005	3300	360	76;119	-	open	OPS, SB, YPD
S49k	20vs40	0.0005	0.005	3300	360	38;60	-	open	OPS-mode 1
S49l	20vs40	0.0005	0.005	3300	360	19;30	-	open	OPS-mode 1
S49m	20vs40	0.0005/0.05	1.6	3300	360	50	-	closed	cooling
S49n	20vs40	0.0005/0.05	1.6	2920/2920	360	TF only [d]	-	closed	cooling

continued on the next page. . .

. . . continued

Run	A_y,A_o	γ_{TF}/γ_c	γ_m	ρ_c/ρ_{TF}	E_a[c]	L_w $(A_y; A_o)$	Test	Bottom BC	Result
S49o	20vs40	0.0005/0.05	1.6	2920/2920	360	TF only [d]	-	closed	cooling
S49p	20vs40	0.00005	1.6	3300	360	1100	-	open	cooling
S49q	20vs40	0.05	1.6	3300	185	0	-	open	cooling
S49r	20vs40	0.05	1.6	3300	120	0	-	open	cooling
S49s	20vs40	0.05	1.6	3300	185	0	-	open	cooling
S49t	20vs40	0.05	1.6	3300	120	0	-	open	cooling
S49u	20vs40	0.0005	1.6	3300	360	1100	-	open	cooling
S49v	20vs40	0.00005	1.6	3300	360	1100	-	open	cooling
S49w	20vs40	0.0005	1.6	3300	360	1100	-	open	cooling
S49x	20vs40	0.00005	1.6	3300	360	1100	-	open	cooling
S49y	20vs40	0.0005	1.6	3300	360	1100	-	open	cooling
S49z	20vs40	0.05	1.6	3300	360	0	ΔT_p =250^{o}C	open	cooling
S50a	20vs60	0.0005	0.1	3300	360	1100	-	open	cooling
S50b	20vs60	0.0005	0.05	3300	360	1100	-	open	Close to OPS
S51a	20vs80	0.0005	1.6	3300	360	1100	-	open	cooling
S51b	20vs80	0.0005	0.1	3300	360	1100	-	open	Close to OPS
S51c	20vs80	0.0005	0.08	3300	360	1100	-	open	Close to OPS
S51d	20vs80	0.0005	0.06	3300	360	1100	-	open	OPS-mode 1
S51e	20vs80	0.0005	0.05	3300	360	1100	-	open	OPS-mode 1
S51f	20vs80	0.0005/0.05	1.6	3300	360	50	-	closed	cooling
S52a	20vs100	0.0005	1.6	3300	360	1100	-	open	cooling
S52b	20vs100	0.0005	0.1	3300	360	1100	-	open	OPS-mode 1
S53a	20vs130	0.0005	0.1	3300	360	1100	-	open	OPS, SB
S54a	25vs40	0.0005	0.05	3300	360	1100	-	open	cooling
S55a	25vs60	0.0005	0.05	3300	360	1100	-	open	cooling
S56a	25vs80	0.0005	0.05	3300	360	1100	-	open	Close to OPS
S57a	25vs100	0.0005	0.05	3300	360	1100	-	open	OPS-mode 1
S57b	25vs100	0.0005	0.075	3300	360	1100	-	open	Close to OPS

[a]If one value only is indicated, the oceanic crust ③ in Fig. 2 is assumed to have the same brittle parameter as the one of the weak material forming domains ① and ②. [b]If only one value indicated, then $\rho_c = \rho_{TF}$. [c]If one value only indicated, L_w is identical on both plates. [d]The weak material is imposed to form the fault zone ① only (Fig. 2). "tw": thermal transition width at the plate boundary. ΔT_p: temperature anomaly within the plume head. ν_{ref}: reference viscosity at the lithosphere-asthenosphere boundary (2.74$\times 10^{19}$ Pa.s). OPS: older plate sinking. YPVSI: YP vertical subduction initiation (as in Fig. 4-6). YP retreat: backward drift of the younger plate (Fig. 4-3). YPS: younger plate sinking (sketched in Fig. 4-4b). Double SI: double subduction initiation (Fig. 4-5). Heavy YPS: subduction of the heavy YP segment (Fig. 4-4a). SB: slab break-off. YPD: young plate detachment from the surface and sinking into the mantle.

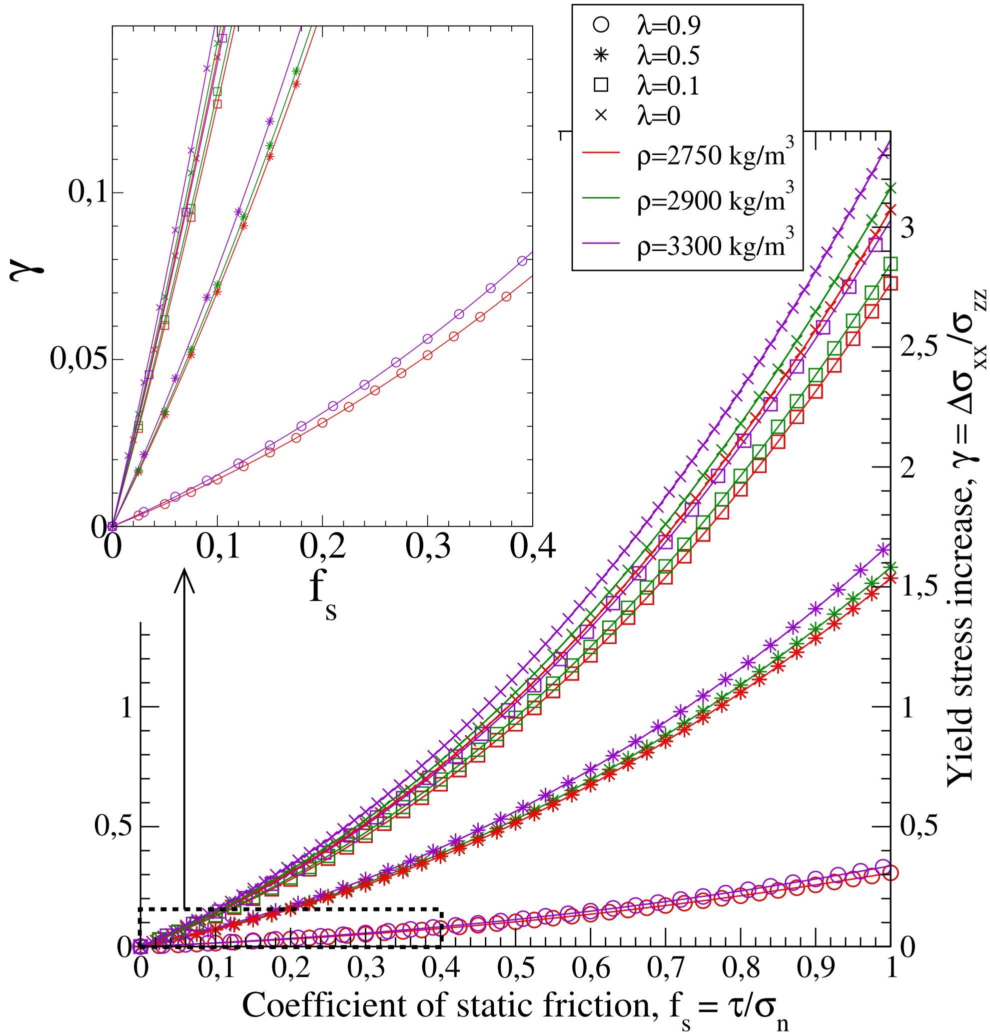

Figure S1. Brittle parameter (yield strength increase with depth), γ, used in eq. 1 to compute brittle stresses. The brittle parameter is a function of rock friction coefficient f_s, rock and water densities, ρ and ρ_w and pore fluid pressure ratio, λ, according to eq. 4 in the main text from Turcotte and Schubert (1982). The inserted graph is a close-up on f_s values <0.4 .

S2 Minimum extent of crust weakening allowing OPS as a function of rheology

We seek for the minimum distance from the TF over which the crust must be weakened (L_w) to allow OPS, in order to compare it to the damage/alteration extent around a TF in nature. As mentioned in the main text, OPS triggering basically depends on plate bending ability, that we assume to depend on the lateral extent of weakened crust. To test it, we first estimate the bending length as a function of the plate age, for the rheological set leading to self-sustained OP subduction (Fig. 6f). Experiments are performed by varying the age A_o of the plate imposed on the left-hand side of the TF while on the other side the asthenosphere is modelled right below the crust base (Fig. S2a). An horizontal profile of velocity computed at mid-depth within the OP is used to estimate the plate bending length (Fig. S2a, top panel): L_0 corresponds to the distance between the infant slab extremity (high velocities) and the location backwards where velocities vanish to zero. The obtained bending length, L_0, roughly increases as the square root of A_0, meaning that L_0 and plate thickness are at first order proportional (Fig. S2b). We next study OPS triggering as a function of the crust "damage" extent for a set of plate age pairs showing OPS when the whole oceanic crust is weakened (L_w =1100 km). These age pairs are selected in order to cover a wide range of YP age (2 to 20 Myr). The area of weakened crust, L_w, is reduced from 1110 km to the respective plate bending length L_0 of each plate, and even lowered down to a fraction of L_0 (1/2, 1/4, and 1/8). For a very thin YP (A_y =2 Myr), OPS is observed without mantle weakening (γ_m=1.6) and the minimum L_w allowing OPS is short ($L_w = L_0/4$ =4 km and 10 km for the plate age pair 2vs5, Fig. S3). When the YP is 5 Myr old, the minimum L_w is L_0, already outside a realistic range ($L_0 =$ 41 km and 274 km for 5vs50). For a thicker YP, the mantle strength must be significantly lowered to enable OPS, as mentioned in Sect. 2.8.4. For a 10 Myr old YP and γ_m lowered to 0.05, OPS does not occur unless the crust recovers the whole box surface (L_w =1100 km, 10vs40). Still, when $A_y = 20$ Myr, since OPS is not allowed if the mantle is not extremely weakened (γ_m reduced to 0.005), OPS triggering does not strongly depends on the extent of weakened crust and is observed as soon as $L_w \geq L_0/8$, that is for weakened domains shorter than 30 km.

We conclude that the domain of weakened crust to impose in the vicinity of the TF to achieve OPS is too large to be realistic, at least for classical mantle rheology, the only exception being a very thin YP (A_y =2 Myr). These results reinforce the strong resistant character of thick YP on OPS triggering.

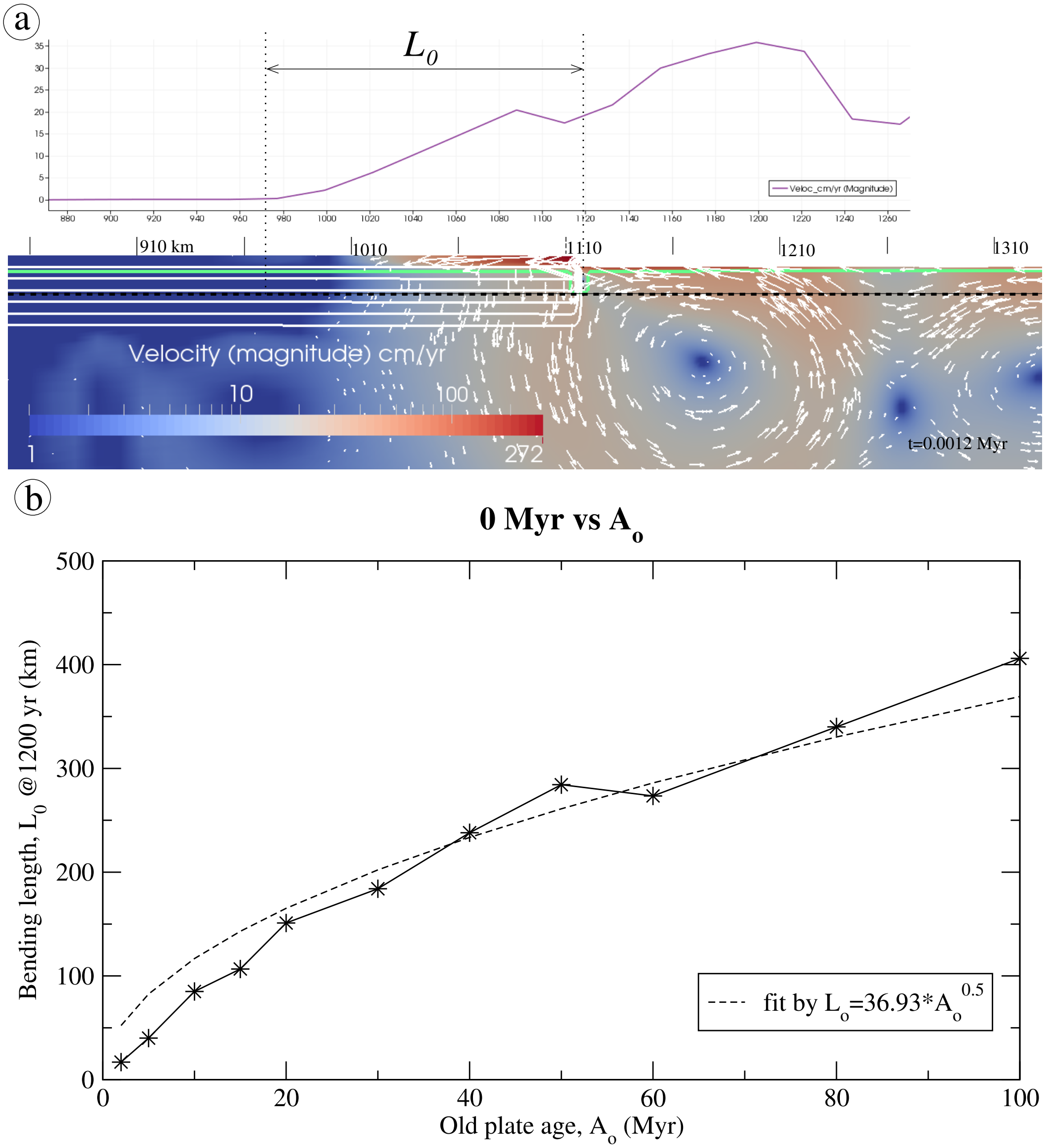

Figure S2. Estimate of the bending length, L_0, as of function of plate age, A_o, when the A_o old plate is facing a layer of asthenosphere at the TF. The set of rheological parameters is the same as used in Fig. 6f: $\gamma_c = 5 \times 10^{-4}$, γ_m =1.6, ρ_c =3300 kg.m^{-3}, ρ_{TF} =3300 kg.m^{-3}, E_a^c =360 kJ/mol, and L_w =1100 km. (a) Example of L_0 measurement in simulation S5a (A_o =20 Myr). Bottom row: Snapshot of the velocity field soon after simulation start (t =1200 yr). Isotherms (white lines) are displayed every 200^{o}C. The green thick line outlines the weak layer. Note that the velocity scale is logarithmic. Horizontal distances are measured from the box left-hand side (no vertical exaggeration). The black dotted line is the horizontal profile at mid-depth within the OP along which velocities are sampled to estimate the plate bending length L_0 (top row panel). (b) Plate bending length L_0 as a function of plate age, A_0, obtained in experiments S1a, S2a, S3a, S4a, S5a, S6a, S7a, S8a, S9a, S10a, and S11a (stars and solid line).

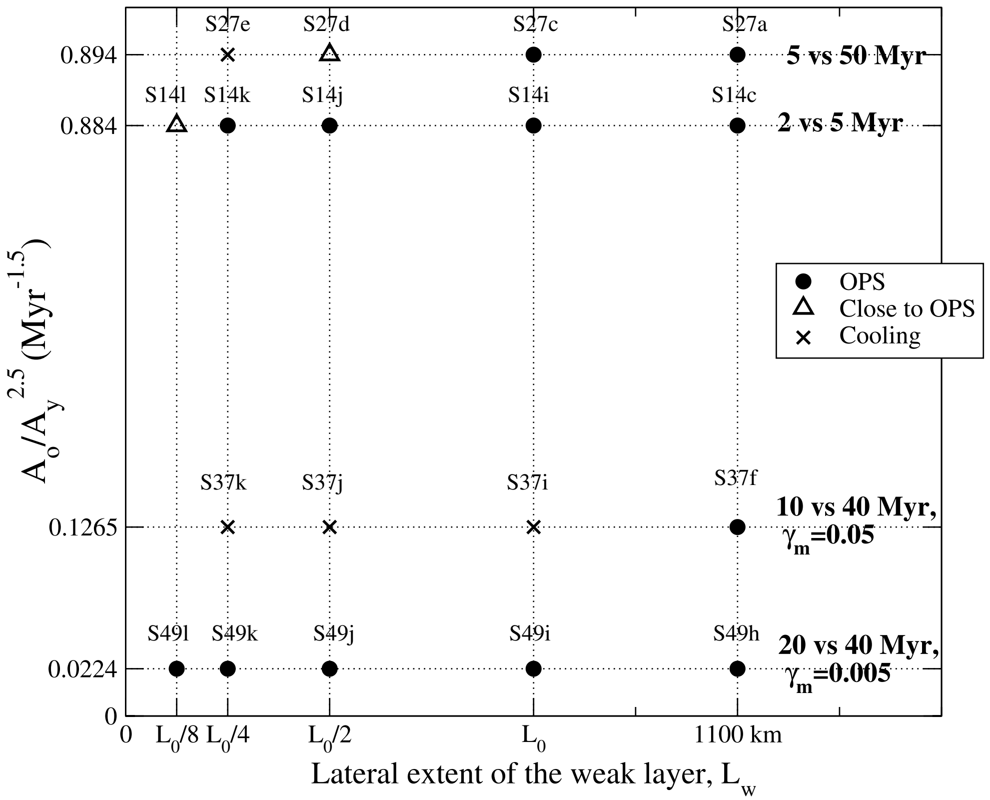

Figure S3. Regime diagram as a function of the crust weakening width, imposed away from the TF, L_w, for 4 plate age pairs and different mantle brittle parameter. L_o refers to the bending length displayed in Fig. S2b corresponding to the plate age A_o. The different plate age pairs (A_y,A_o) are depicted by a single parameter, $A_o/A_y^{2.5}$, that can be used to predict OPS occurrence for a normal mantle brittle parameter (γ_m =1.6) and for an oceanic crust assumed to be weakenened over the whole plate surface (Fig. 6f). Note that the $y-$axis is not scaled.

S3 Additional tests on OPS conditions: TF gouge strength and width; TF vs fracture zones; and asthenosphere viscosity

We sum up in this section extra experiments performed to precise the mechanism involved in OPS triggering.

We first test the necessity of the fault softness to simulate OPS, by inverting the oceanic crust and TF respective brittle strength (γ_{TF} =0.05 instead of 0.0005, while γ_c is set to 0.0005). For the plate age pairs 2vs5 and 2vs40, OPS is either prevented or postponed to the end of a first YP sinking stage when the TF gouge brittle coefficient is not drastically reduced (sim. S14s and S17u). The TF strength is thus critical to model OPS. We next wonder if OPS could be triggered by widening the fault gouge from the surface to the bottom of the fault (domain 1 in Fig. 2), by setting the fault width to 20 km instead of 8.3 km, for 2 plate age pairs: (A_y, A_o) =5vs15 (simulation S22t, $\gamma_c = 5 \times 10^{-5}$) and (A_y, A_o) =10vs40 (simulations S37r, with $\gamma_c = 5 \times 10^{-4}$ and S37s, $\gamma_c = 5 \times 10^{-5}$). Simulations show that OPS does not occur, even if the mechanical decoupling is maximized. The mechanical interplate decoupling is hence not sufficient to trigger OPS alone.
Subsequently, we investigate the possible role of the TF thermal structure. We assume that the interplate domain is very thin, since it is modeled by a stair-step (Sect. 2.2). In nature this set-up would correspond to an active transform fault. If the fault is instead inactive, the thermal state at the plate boundary is likely to be cooled by thermal conduction, and consequently possibly stronger and more resistant to plate decoupling. Besides, the fault thermal structure may depend on the distance between the spreading ridge and the location where the TF cross section is considered (Behn et al., 2007). We test the influence of the thermal structure of the TF for the plate age pair 2vs80 for which OPS is simulated if the crust brittle parameter γ_c is 0.0005. While for the stair-step case the width of the transition between the 2 plates is close to zero (simulation S18b), we widen the TF thermal transition to 11 km (sim. S18b2), 30 km (S18b3), 50 km (S18b4), and 70 km (S18b5), keeping the weak material forming the fault gouge at the center of the thermal transition in all cases. In the same way, the thermal transition width is enlarged to 11 km for 2vs5 in simulation S14d (0 km in S14c). All these experiments show OPS. We here verify that the fault gouge weakening, governed by the weak material brittle properties, is independent of temperature, and at first order independent of the fault activity in our 2D set-up. Similarly, the YP vertical sinking occurs for a stair-step transition (simulation S18a) as well as if the thermal transition width is set to 11 km (sim. S18a2).
We finally test if a decrease in asthenosphere strength could help OPS triggering, as the asthenosphere viscosity should resist plate sinking. For one plate age pair yielding cooling only, even if the crust brittle parameter is significantly decreased (5vs15, simulation S22h), the reference asthenospheric viscosity is decreased by a factor 5, while for 2 other plate age pairs (10vs40, S37b2 and 20vs40, S49f), a factor 10 is applied. Experiments show that asthenospheric velocities and OP deformation are slightly amplified but still not enough for OPS to be triggered.

S4 Modes of OPS

In Sect. 3.1 we analyse the velocity fields simulated during modes 1 and 2 (Fig. S4) and show that these modes of OPS initiation are associated with a particular YP kinematics. Mode 1 is related to a roughly motionless YP remains while asthenospheric velocities are high ($\geq$ 20 cm/yr, Fig. S4) and focused at the TF towards the OP surface. Furthermore, velocities are not homogeneous along the YP but slighly increase towards the TF. On the contrary, in mode 2 the velocity field across the YP is homogeneous but also roughly constant from the YP base to the asthenosphere where speeds are high (between 25 and 100 cm/yr). Moreover, within the set of simulations showing OPS (Sect. 3.2), we find that mode 2 occurs when A_y $\leq$2 Myr, for various rheological sets, or if A_y =5 Myr, provided that the mantle brittle parameter is reduced. In all these experiments, the viscosity ratio between the lithospheric mantle strength at the Moho and the asthenospheric viscosity (10^{18} Pa.s in most experiments) is $\lesssim 10^2$ to 10^3 (Fig. S5). Hence the strength of the YP bottom part is the closest to the asthenospheric one in mode 2. On the contrary, the focusing of asthenosphere flows at the TF in mode 1 is observed when the viscosity offset between the YP mantle and the underlying mantle exceeds 10^3. We conclude that mode 2 takes place by a stronger coupling between the YP and the asthenosphere. Still, as slab roll-back during OPS is all the faster than the OP is aged, the crust transfer in mode 2 from the YP towards the OP gets hampered at some point for thick OPs. A switch from mode 2 to mode 1 is then observed in some experiments (S16f; S17c,n; and S18p, Table S1).

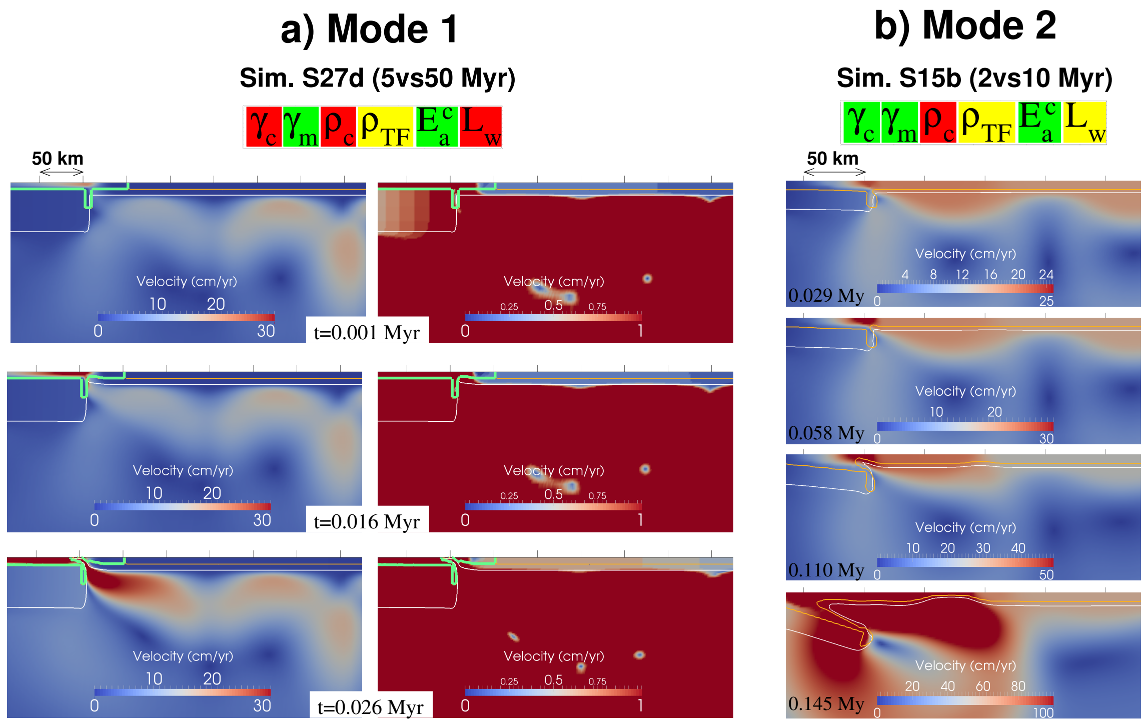

Figure S4. Velocity field obtained (a) in Simulation S27d illustrating mode 1 OPS and (b) Simulation S15b illustrating mode 2 OPS. White line: 1200^{o}C isotherm. Yellow line: boundary between the mantle and the oceanic crust. Green thick outline: limit of the weak material. Note that in panel a, velocities are saturated to 1 cm/yr in the right-hand column to highlight low speeds within the younger plate. No vertical exaggeration.

Similarly, several simulations performed with A_y =0 Myr show an OPS initiation following an intermediate mode: the kinematic coupling YP/asthenosphere is less clear, and velocities are not laterally transferred far away from to TF. To understand this result, one may notice that in this particular case the 1200^{o}C isotherm (considered as the lithospheric base) is located at 5 km depth, i.e., shallower than the modelled Moho (8.3 km). The YP plate for A_y =0 Myr is thus mainly a "crustal plate" devoid of a mantle base, and, depending on the strain-rate, more or less significantly weaker than the asthenosphere (Fig. S5). The mechanical coupling between the YP and the hot mantle is high in simulations S1a to S2b (considered as mode 2 OPS), but is not continuously strong through time in simulations S3a to S11a (Table S1). To simplify these later experiments performed with A_y =0 Myr are considered as mode 1 OPS .

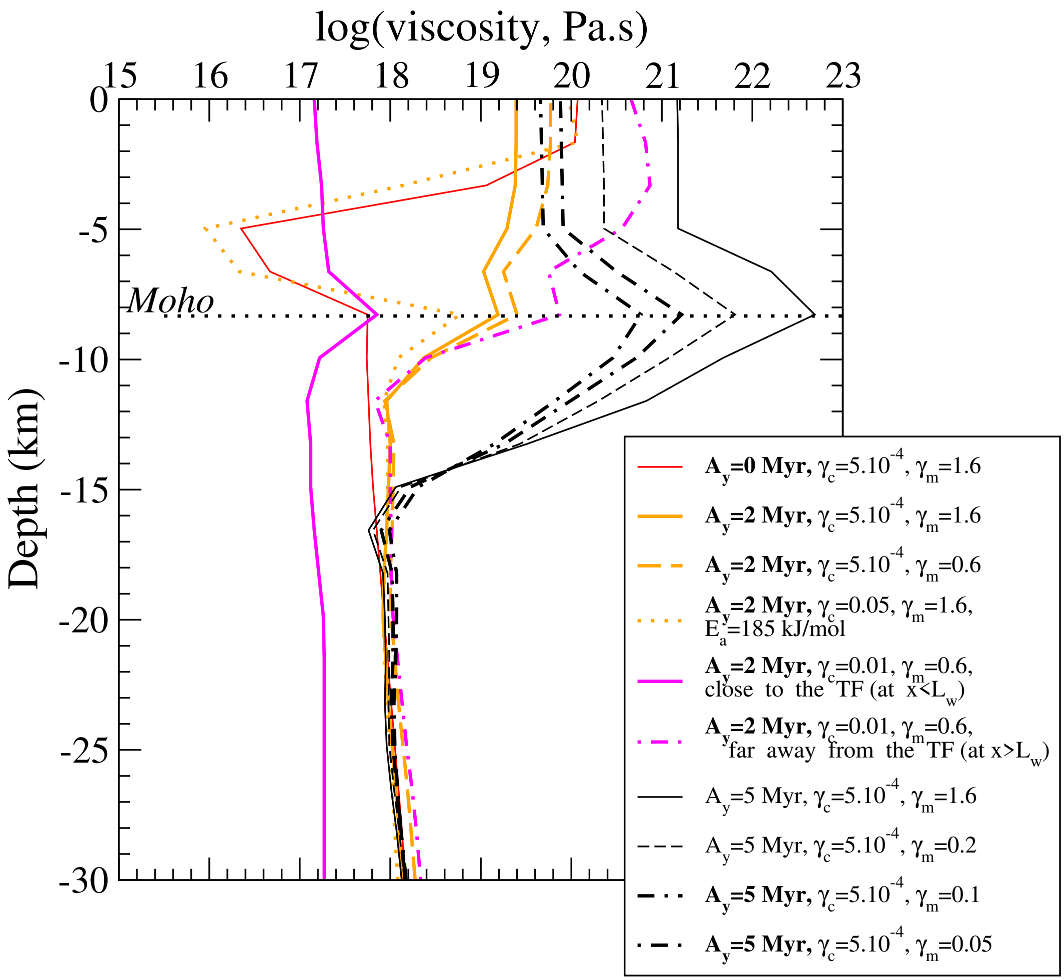

Figure S5. Viscosity profiles at simulation start as a function of plate age and rheological set. When not mentioned, profiles are computed at the center of the plate (555 km away from the closer vertical box boundary). The asthenospheric viscosity is 10^{18} Pa.s in most experiments, but may vary as viscosity is strain rate-dependent in our model. Thick lines and bold polices are used for viscosity profiles corresponding to a mode 2 initiation where the considered plate is the YP.

References

Behn, M., Boettcher, M., and Hirth, G. (2007). Thermal structure of oceanic transform faults. *Geology*, **4**, 307–310. 10.1130/G23112A.1.

Turcotte, D. and Schubert, G. (1982). *Geodynamics: Applications of continuum physics to geological problems*. Cambridge University Press, New York, second edition.